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PROCEEDINGS

of the

NATIONAL

RICE UTILIZATION

CONFERENCE

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Held at

New Orleans, Louisiana

April 5 and 6, 1966

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

PREFACE

The 1966 National Rice Utilization Conference was held April 5 and 6, 1966, at the Fontainebleau Motor Hotel in New Orleans, La. This Conference was sponsored jointly by the Rice Millers' Association, the American Rice Growers Cooperative Association, and the Southern Utilization Research and Development Division of the Agricultural Research Service, U. S. Department of Agriculture. The purpose of the Conference was: (1) To acquaint those interested with current developments in rice research, production, marketing, and utilization, and (2) to provide for an exchange of information that will benefit industry and future research. As the title suggests, emphasis was placed on utilization research. Utilization research is constantly developing new ideas and products that show great possibilities of benefiting both industry and consumer. Its successful accomplishments, however, are more likely to materialize when there is an understanding of the specific difficulties being encountered by each segment of the industry-from breeder and producer of raw materials to reprocessor and finished product distributor.

A wide range of topics was selected by the Program Committee. These, hopefully, were designed to reveal many of the problems that exist in the diverse segments of the rice industry and to reveal their interrelationships in processing from rice breeder to user. The papers presented are a measure of the success in the attainment of the purpose of the Conference. They bring greater understanding, provide pertinent guidelines, and offer invigorated inspiration for the betterment of the rice industry and consumer welfare.

Underscored numbers in parentheses refer to literature cited (placed at end of each paper) by the author. The citations, figures, and tables are reproduced essentially as they were supplied by the writer of each paper.

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Proceedings of the National Rice Utilization Conference
Held at New Orleans, Louisiana, April 5 and 6, 1966

OPENING SESSION: J. P. Gaines,[1] General Chairman

INTRODUCTORY REMARKS
by
J. P. Gaines

It is my pleasure to open the National Rice Utilization Conference.

This Conference is concerned with a special kind of research called utilization research. Utilization research is research ready to be used by industry in turning out a new product or a better product or the same product at a lower cost.

Stated simply, rice utilization research is aimed at increasing the uses and usefulness of rice.

To us in the rice business, increasing uses or increasing usefulness means more markets and more sales. Such research thus has a direct financial meaning to the rice industry.

Rice utilization research is done by our Government laboratories, by rice mills, by food and beverage companies, and by industrial firms.

The Program Committee, which arranged this Conference, tried to include a cross section of all the interests that are involved in utilization research on rice.

The purposes of this Conference are several:

1. To acquaint people in the rice industry with some things that are being done by the Department of Agriculture's utilization research laboratories.

2. To give advice and guidance of the industry to the scientists who are working in the Government laboratories.

3. To enable an exchange of ideas between research scientists in the Government and industry and between the scientists and trade people.

4. To establish communications between all parties that are interested in utilization research on rice.

If this Conference produces just one new idea, it will be worth all the effort that has been put into it. I am sure that with all the talent and brainpower that has been assembled here, more than one new idea will be born.

We have many fine speakers on the program of this Conference. However, the program is not limited to these speakers; it includes you as well. There will be an opportunity for questions and answers and group discussion throughout the Conference. You will get out of the Conference what you put into it. Ask the questions that come to your mind. Don't worry about whether they may sound good or bad to other people. We from the rice industry don't know much about research, but let's not let that stop us from joining in the discussions. On the other hand, the folks in the research operations may not know much about the trade operations of the rice industry, but don't let that stop you from asking questions on trade matters.

Not many people are expert in more than one field. Everybody here is an expert in some field. Nobody expects us to be an expert outside our field.

This Conference is sponsored by three organizations--the Rice Millers' Association, the American Rice Growers Association, and the Southern Regional Research Laboratory here in New Orleans.

It is my privilege at this time to bring to you the heads of the respective sponsoring organizations for some introductory remarks.

WELCOME
by
C. H. Fisher, Director
Southern Utilization Research and
Development Division

It is a real pleasure and honor to welcome this splendid audience to the National Rice Utilization Conference on behalf of the Southern Division.

[1] The Rice Millers' Association, Washington, D. C.

Dr. Fred R. Senti, who administers all USDA consumer and industrial use research, asked me to give you his greetings and to say that he regrets he could not be here this morning to welcome you in person. As indicated by the program, he will be with us tomorrow morning when he will review USDA research on cereals.

The year 1966 is particularly appropriate for our National Rice Utilization Conference. In the first place, 1966 has been named International Rice Year; and the period of March 13-19 was celebrated as National Rice Week.

The lives of more than 1 billion human beings are dominated by a single word--Rice. They are the rice-eating people of the world, for whom rice is the mainstay of their diets, nearly all of their agriculture, and much of their hopes. It is to them that the Food and Agricultural Organization has dedicated the 12 months of 1966 as International Rice Year. The United States is 1 of the 16 countries to designate a National Rice Week.

The year 1966 seems to be ending an era of agricultural surpluses, except for cotton, and beginning an era in which the total demand for food--domestic and foreign--will exceed our production of food.

Grain surpluses have been sharply reduced, the tobacco carryover has been going down, and, even with large stocks of cotton, the carryover stocks of farm commodities is lowest since 1957. Wheat carryover at the end of this marketing year will be about 750 million bushels, down almost 50 percent from the record 1.4 billion bushels on hand in 1961. Feed grain stocks have been reduced nearly one-third. Surpluses are disappearing.

It is becoming more apparent in 1966 that the world's population explosion will have a tremendous influence on agriculture and international affairs. It has been estimated that in 14 years there will be a billion more mouths to feed in the world. People will need 300 million more tons of food grains than now are produced; that is, as much as is grown now in the United States, Canada, and Western Europe.

It has been made clearer in 1966 that the United States will continue to be responsive to the world's need for food. On February 10 of this year, President Johnson, in his Foods for Freedom Message to Congress, said, "I propose that the United States lead the world in a war against hunger. Unprecedented demands arising out of drought and war in Asia require us to increase our rice crop this year." On that same day, the U.S. Department of Agriculture authorized an increase of 10 percent in the national rice acreage allotment for the 1966 crop year.

Rice, the world's most important food, is particularly suited to meeting the world's food needs. Rice, produced in greater abundance than any other food crop, is the principal source of nourishment for a greater number of people than any other food. More than half of the world's population consume rice as a principal source of nourishment. Rice is indeed an amazing food when one considers that it has been the principal sustenance for half the people of the world for thousands of years.

Our agricultural exports are growing in 1966. In the current fiscal year, they will go above $6 billion for the third year in a row--perhaps to another new high of $6.5 billion. By 1970 the value of our farm exports can well reach the figure of $8 billion per year--with three-fourths of it for dollars. Agricultural exports, currently about 25 percent of all U.S. exports, are vital to improving our Nation's balance of payments.

The year 1966 finds our Nation in its fifth year of an economic boom and prosperity without equal in all history. In the last 5 years the gross national product (GNP) has increased by $190 billion to about $720 billion. Our economy is so vast that 1 year's increase in our GNP exceeds the total annual output of all but 7 of the other countries in the world. This prosperity is reflected in a healthy increase in living standards. Although the cost of living has gone up 6.6 percent since 1960, individual income has increased an average of 23.4 percent per person. Economists say that our economy will grow faster over the next 15 years than at any time in the past half-century.

The year 1966 has special significance for us in the Southern Regional Research Laboratory (SRRL) because 1966 marks the twenty-fifth anniversary of the Laboratory's existence. The first several years of the Laboratory were concerned largely with assembling facilities and staff and conducting

research on problems related to defense. For these reasons, our Laboratory has been engaged in strictly agricultural research for about 20 years.

Because this is a utilization research conference, it should be appropriate to mention that the objectives of utilization research in the U. S. Department of Agriculture are to help farmers derive more income from their crops, to provide industry with new or improved products and processes, and to benefit the consumer by creating a greater diversity of useful products at lower cost for better living.

Both the Western Regional Research Laboratory in Albany, Calif., and the Southern Regional Research Laboratory conduct a coordinated program of utilization research on rice. Because major emphasis at the Western Laboratory is given to fruits and vegetables and at the Southern Laboratory to cotton, the research effort on rice at each of these Laboratories is a small proportion of the total effort. For example, three scientists in SRRL, representing 1 percent of the total program, are doing research on rice.

While speaking of utilization research, I would like to emphasize the important role of industry in this area. In the first place, industrial research has been largely responsible for many new or improved products and processes. Research developments from the Western and Southern Laboratories attain their full value only when industry applies them in the manufacture of new or improved products.

During this and other occasions, the members of this Conference are cordially invited to visit our Laboratory, meet with our scientists and engineers, make suggestions, and mention individual problems of special interest. We also shall be pleased for you to become better acquainted with our work on other commodities, such as cotton, cottonseed, sweetpotatoes, and peanuts.

I wish to thank the rice industry not only for interest and help in connection with our research, but also for valuable assistance in planning and arranging this National Rice Utilization Conference. I wish to express gratitude particularly to the General Chairman, J. P. Gaines; the Program Committeemen, George B. Blair and Kenneth K. Keneaster; President Jack R. Smith, of the Rice Millers' Association; President D. R. Wintermann, of the American Rice Growers Cooperative; those on the program as chairmen and speakers; and that indispensible part of a conference; namely, you, the members of the audience.

My expression of gratitude extends also to Alan D. Berg, of the State Department; Fred R. Senti, from the Agricultural Research Service in Washington; and those members of the Southern Utilization Research and Development Division who have contributed to the success of our Conference.

OPENING REMARKS
by
C. Smith [1/]
representing
J. R. Smith [2/]
and
D. R. Winterman [3/]

[Messrs. Smith and Wintermann made extemporaneous remarks welcoming the attendees to the Conference and expressing their personal pleasure and that of their respective organizations in being cosponsors of the Conference. They further stated that the program was an excellent one and that the entire rice industry would benefit from it.]

1/ General Sales Manager, Arkansas Rice Growers Cooperative Association, Stuttgart, Ark.

2/ President, The Rice Millers' Assoc., Crowley, La.

3/ President, American Rice Growers Cooperative Association, Eagle Lake, Tex.

FIRST SESSION: G. B. Blair,[1/] Chairman

RECENT RICE RESEARCH DEVELOPMENTS AT THE SOUTHERN REGIONAL RESEARCH LABORATORY

by
H. J. Deobald
Food Crops Laboratory
Southern Utilization Research and Development Division

In reviewing rice research at this Laboratory, the differences in the concept or image which we have of rice today, as compared with a few years ago, was really surprising. For example, in studying rice quality for the Foreign Agricultural Service (FAS), USDA (9) studies in 1960-61 on foreign rices in commerce, we conducted such standard analyses as iodine-color, protein, amylose, amylopectin, surface lipids, and total starch. Each of these tests was more or less vaguely connected with processing (cooking) characteristics, and it was felt that the results would give us an indication of the quality of the rice preferred in specific foreign countries. Now, we are putting our emphasis on viscosity characteristics, cooking time, nutrients, and the composition of the surface layer of milled rice. From a milling standpoint, rice was, at the time of the FAS study, composed of the hull, bran, polish, and the residual milled rice with a minimum amount of brokens. Now, already identified, are a new series of layers in milled rice which might be designated as a high-oil, high-protein layer; a low-oil, high-protein layer; and a high-starch, low-protein inner core. The outer layers may be milled off in the future. These layers may have further subdivisions when we know more about the ash, oil, vitamin distribution, and nutritional properties, as well as the protein. Even the starch is not uniformly distributed nor of uniform composition. The rice kernel has indeed become a much more complicated commodity.

We have been emphasizing quality and convenience since our work on the FAS project. First, considerable effort was put on the effect of freezing (7) in processing for making a quick-cooking rice. Also, we had a project on the influence of gas plasma irradiation (1, 8). Quite remarkable changes are induced in rices heated in a vacuum and subjected to a glow discharge. Our principal effort up to about 2 years ago was the study of the effect of aging on the changes in rice. Rice does change in cooking quality during aging, and this difference in cooking quality can be consistently measured by any one of a number of tests that do not depend on subjective opinions such as taste panels. We reason that if we can correlate these measured changes in cooking quality with changes in the rice chemistry--that is, change in chemical composition--we could furnish the key to the solution of the problems as to how to make tailormade rice. We want to know how to change the cooking characteristics of any rice so that it can be made suitable for any market preference. The aging project was partly successful in that we found a means to induce a change comparable to aging in rough or in milled rice by heating the rice to around 100° C. for about an hour in a tight container (5). A patent (4) was granted on this process. We did not, however, obtain much information towards finding the mechanism or even the constituent changes in the rice, which bring about the change in cooking characteristics. A great deal more basic information is available now and we hope some day to reactivate the aging problem. Aging is being held as a reserve tool for later use. The aging project was discontinued because of a progress report from Dr. Primo in Valencia, Spain, who was working under the P. L. 480 program which Dr. Golumbic will review in a few minutes. In the first report from Spain it was stated quite clearly that the outside of the milled rice kernel was high in protein. While this was not a new concept, his statements were so positive that both the Southern and Western Utilization Laboratories realized that here might be a real significant difference in the protein content of the outer layer of milled rice. If this were so and this outer layer could be removed as a high-protein flour, it might be that a high-protein rice concentrate could be derived which would fit into the UNICEF program for undernourished children and also be a nutritive concentrate for baby foods and perhaps furnish a relatively high-protein nonallergenic food. Our first attempt

1/ American Rice Growers Cooperative Association.

at removal of a high-protein fraction was the use of the regular McGill milling machine to rub off more of the surface of the rice by prolonging the milling time, or pressure, or both. This resulted in nicely polished rice and a lot of brokens but no flour. We, therefore, set up a machine shown in figure 1. In the first version of the unit we used

Figure 1.—Tangential-abrasive milling apparatus. Left, assembled apparatus during operation; right, unassembled apparatus showing knurled disc, glass tubing filled with rice, and motor without the collector housing (2).

the sandpaper disk attached to the horizontally rotating metal surface and obtained high-protein flour but it was contaminated with sand from the sandpaper. Analysis of this mixture showed us we were on the right track, however. Next we knurled the metal disk itself to prevent the contamination and obtained good samples (2). The rice is placed in the vertical glass tube and the rotation of the disk against the column of rice circulates the rice in such a way that there is a uniform abrasion of the kernels. The protein values of the removed flour were as high as 20 to 21 percent by this method. I should mention also that we used this machine on wheat, barley, and grain sorghum and were able to separate high-protein layers from the outside of these grains as well (6). Analysis of the various layers of flour abraded from brown rice is shown in table 1. Here we remove a total of 41.4 percent of the weight of the kernel in 8 fractions of approximately 5 percent in each fraction. The layer that was taken off between 35 and 40 percent, the eighth layer, had about the same protein content as the original rice. However, the first 3 layers, 15 percent of the outside, had more than twice as much protein as the original rice. The outer layer was mostly bran and was somewhat lower in protein than the next layer, the first fraction one would obtain from abrading conventionally milled rice. In table 2 the data on a commercially milled, long-grain rice bought locally at retail are shown. We did this to eliminate any possible bias which we might introduce in milling the rice to a standard commercial degree in our laboratory. This rice had a lower protein content but the outer 10 percent still averaged 17 percent which was over twice as much as the original sample. In general the higher the protein content of the rice, the higher the protein content in the outer layers, in about the same proportion.

Table 3 shows an evaluation of the residual kernel. After removal of 7 percent of the outer portion of the kernel which

Table 1. --Weight and protein content [1] of successively removed fractions of Bluebonnet 50 brown rice. (2)
(dry-weight basis)

Item	Unit	Successive fractions removed							
		1	2	3	4	5	6	7	8
Kernel weight removed	pct.	4.52	5.60	5.54	5.88	5.56	6.32	4.88	3.12
Total cumulative weight removed	pct.	4.52	10.12	15.66	21.54	27.10	33.42	38.30	41.42
Protein in fraction	pct.	16.24	21.01	19.64	17.37	15.05	12.38	10.12	8.60
Amount of total protein in fraction	pct.	8.36	13.41	12.39	11.63	9.53	8.91	5.63	3.05
Total cumulative amount of protein removed	pct.	8.36	21.77	34.16	45.79	55.32	64.23	69.85	72.90

1/ Protein content of brown rice = 8.78 percent; protein content of residual kernal = 4.93 percent.

Table 2. --Weight and protein content [1] of successively removed fractions of conventionally milled rices (2)
(dry-weight basis)

Item	Unit	Successive fractions removed							
		1	2	3	4	5	6	7	8
Kernel weight removed	pct.	4.23	6.27	3.93	3.74	4.03	7.30	5.83	4.57
Total cumulative weight removed	pct.	4.23	10.50	14.43	18.16	22.19	29.49	35.32	39.87
Protein in fraction	pct.	18.92	15.97	14.96	14.16	12.40	10.74	8.69	7.46
Amount of total protein in fraction	pct.	9.89	12.38	7.27	6.53	6.18	9.69	6.26	4.21
Total cumulative amount of protein removed	pct.	9.89	22.27	29.54	36.07	42.25	51.94	58.20	62.41

1/ Protein content of milled rice = 8.09 percent; protein content of residual kernal = 5.06 percent.

Table 3. --Quality evaluation of residual kernels after successive removal of selected fractions (2)

Item	Unit	1	2	3	4 1/
Kernel weight removed	pct.	6.80	14.99	25.50	0
Protein content of residual kernels	pct.	7.74	6.31	5.59	8.09
Cooking time	min.	17	17	17	17.5
Organoleptic rating	score 2/	32.0	30.3	29.4	31.5
Sedimented solids loss	ml.	1.80	2.48	2.60	2.08

1/ Control sample of conventionally milled rice.
2/ Highest total rating score = 35.

contained about 18 percent protein, the deep-milled rice protein content was still 7.74 percent as compared to 8.1 percent in the whole rice originally. I emphasized this because many people have been concerned that a major portion of the protein must be removed when one takes off the outer 7 to 8 percent. The actual amount of protein removed is not great and the residual rice still has a reasonably good protein level. This deep-milled rice has a slightly shorter cooking time and is rated "better than the original milled rice" in acceptability after cooking and there was less loss to the cooking water. The removal of larger amounts than 8 to 10 percent seems to lower the acceptance somewhat. Dr. Primo who is working on the P.L. 480 project on the quality characteristics has come to a similar conclusion. He states that the inside of the rice is best for processing and is the most stable and the outside should be food for children and the sick.

The next step, of course, was to find a means for getting larger samples so that the nutritional aspects of the flours could be studied by actual feeding, and so that some of the properties of the various layers might be further investigated. For this purpose we requested our Cotton Mechanical Laboratory personnel, to design a machine which would give us a greater yield by exposing more rice to the action of the knurled surface. They designed a machine (figure 2) which is a knurled cylinder about 8-1/2 inches in diameter and 20 inches long. It has a stripper bar in the center and stripper bars on either side forming the supports for framing two hoppers. We found that by putting 25 pounds of milled rice in the front side, where the circulation of rice is against the stripper bar and then to the outside of the hopper, and by using a rotation speed of about 500 r.p.m. good action of the rice in the hopper resulted. We could process the 25 pounds at one time. We made over 100 pounds of flour on this machine before it was abandoned. It did not break the rice appreciably but we did notice that there was more coarse material which would not pass through an 80-mesh screen. This coarse material we call chits. The chits are usually about 3 percent lower in protein than the 80-mesh flour from which it was separated. The next question was: Is this process feasible on a commercial basis? There are several rice milling machines used by the industry which have the abrasion principle for milling rather than the pressure contact principle. The Olmia and the Satake machines are outstanding examples. We decided to use a Satake primarily because it was available. A commercial miller agreed to prepare several samples on the machine. Figure 3 shows the typical installation of a Satake rice whitening machine. The feed hopper is on the front side and the feed discharge at the far end with the flour collection directly under the machine. The slotted cage surrounds the inner carborundum cylinder. These cylinders rotate on a shaft within the slotted housing and abrade the rice as it passes through. One pass will yield 3 to 4 percent of the rice as flour, but it takes 3 to 4 passes to get 8 percent of the weight

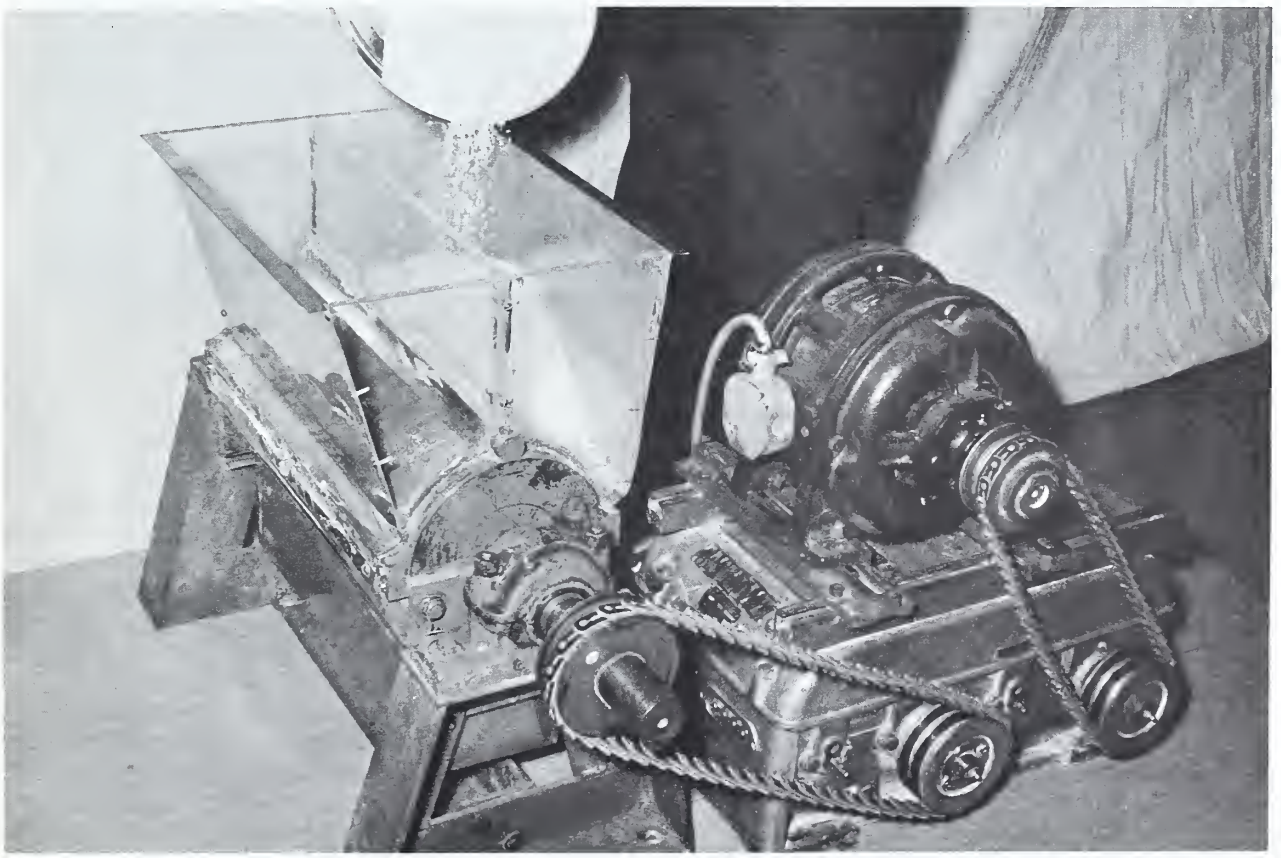

Figure 2.—Experimental model abrasion-type rice milling machine showing cylinder with knurled surface.

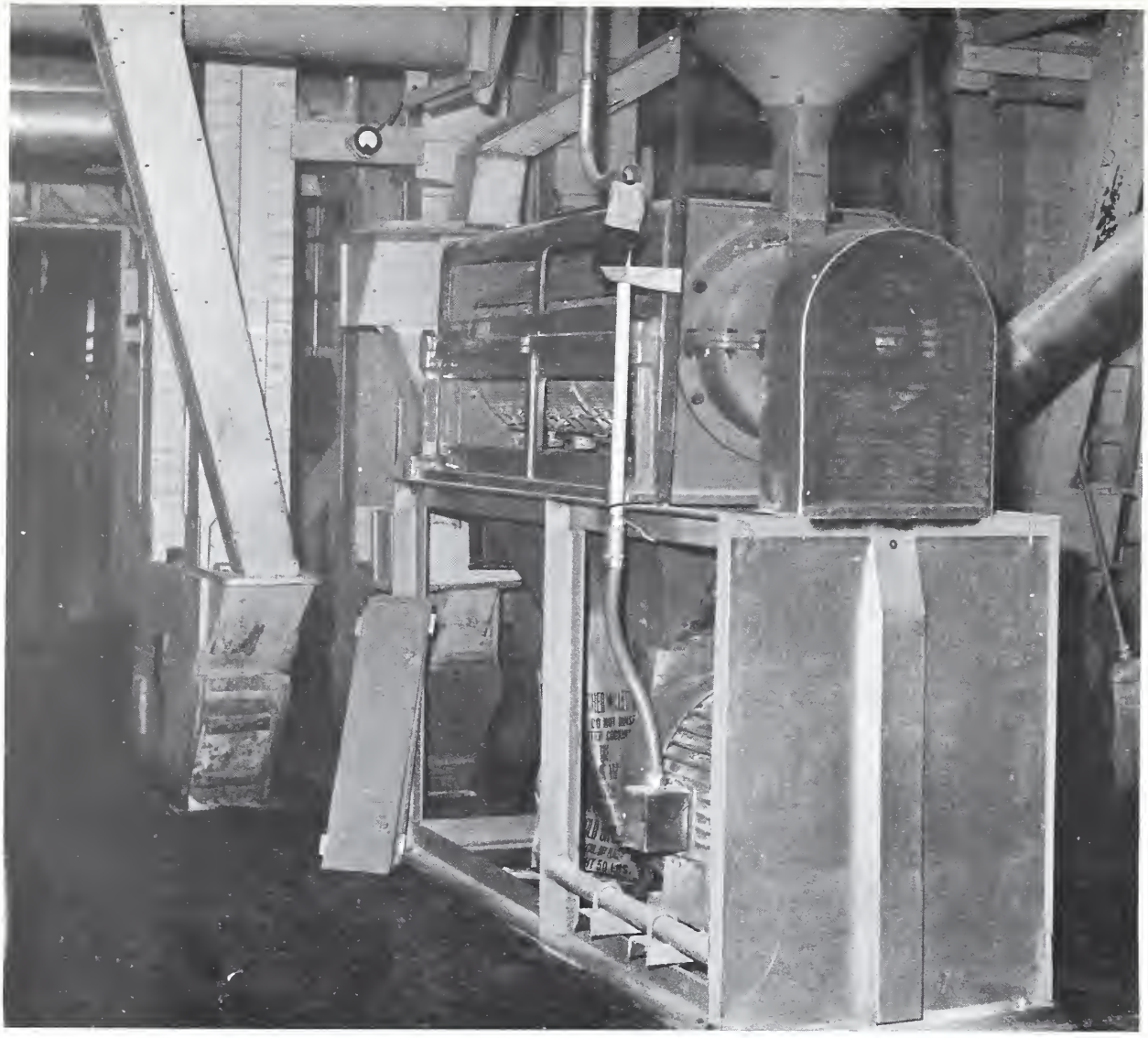

Figure 3.--Commercial installation of a Satake Rice Whitening Machine.

as flour. Evidently the rice grain is more resistant to abrasion the nearer one approaches the center. When properly used, there is very little breakage but the chits content is sometimes as much as 50 percent. A finer carborundum should improve this condition. Personnel of our Engineering and Development Laboratory, (SURDD) on examining the data obtained, estimate that between 4 and 5 tons per hour can be run through the machine without overheating the rice, and that in a 1-pass system, the cost to produce 1 pound of flour would be about 2 cents. If 8 percent were removed, the cost would be about 3 cents per pound, which to us means good commercial feasibility. Second heads or broken rice also make a high-protein flour. The next question for us, and I hope now for you, is what is this flour good for? Where can it be used? To answer this we are working on the characteristics of the flours from the various layers that have been removed. We have found some very unusual viscometric properties unlike those of any rice flour from ground whole rice or brokens. The vitamins, lipids, calcium, and phosphorus are also concentrated in the outer layers, to an even greater extent, than the proteins. Samples of these high-protein rice flours are being distributed to food processors for evaluation. As stated, the appearance and cooking characteristics of the residual rice, if not more than 8 percent is removed, is at least equivalent to milled

rice before deep-milling, and many of us are willing to say that the deep-milled rice is actually a nicer cooking rice than the original rice from which it came.

Another unrelated project should be mentioned. Our Engineering and Development Laboratory is conducting work on popped rice to determine if a product or products can be prepared that may be of interest to the rice industry. That is, to determine if there are some unusual characteristics in the popped rice that may make it of special value. Popping rice is not new. It is prepared locally in India but there is no known commercial operation. It cannot compete in price with popped corn, but it has a mild and pleasant taste. Waxy (glutinous) rices pop best but the long-grain rices also pop to some extent, Narayanswami (3), in his book, describes the method of popping by heating the rice in hot sand and sifting it to remove the sand. This work is in the preliminary stages.

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RECENT RICE RESEARCH DEVELOPMENTS AT THE WESTERN REGIONAL RESEARCH LABORATORY

by
J. W. Pence
Western Utilization Research and Development Division
Albany, Calif.

My assignment today is to review briefly for you some recent accomplishments of our rice research program at the Western Laboratory. Although our program is small, it is properly a broad program. We endeavor to make it a productive program and one that is responsive to the needs of the rice industries and the general public. I am pleased to note that all of the items I will discuss relate more or less directly to other topics appearing later on the program.

Utilization research, as was pointed out by Mr. Gaines, is primarily concerned with products and processes--new ones or improved ones. Which they are is really

less important than whether they are responsive to a need or a problem of the industry. I will, therefore, discuss several items in relation to particular problems. First, however, I want to comment that while something might be construed as a problem, it is also proper to regard it as an opportunity. In fact, the bigger and more pressing a problem may be, the more opportunity it presents for research to be productive.

In this type of context, then, I will discuss results from five lines of our current work, as follows:

(1) A new method for removing bran from brown rice--a new milling method, I suppose it could be called--a chemical milling method.

(2) A simple way to build extra nutrition into rice to make it even more useful in our food aid program overseas. The emphasis will be on protein fortification.

(3) How the high protein flours from the deep milling of rice can be made more useful by converting them to beverage and gruel types of products.

(4) An entirely new process for preparing a quickcooking rice for the domestic convenience market. It may be less expensive than any present method.

(5) Some of the recent interesting findings from our fundamental work on the chemistry of rice proteins.

The new bran removal method is one that was recently developed by our Engineering and Development staff under the leadership of A. I. Morgan, Jr. The process makes use of ordinary household lye to remove the bran and other skins from grains. The process has been named the WURLD process because it makes use of a whirling type of agitation and because it reflects the initial letters of our Western Utilization Research and Development Division and Laboratory. The process works well with several grains but has some particular advantages for rice.

The process is a wet process and a very wet one--lots of water is used. Other new milling methods being used and developed in the industry have been referred to as wet processes because they make use of liquid solvents and oils. To my knowledge, they do not use water. As I mentioned, our process involves the use of lye to remove the bran from brown rice--lye, the same old caustic or sodium hydroxide that is used for soap making, for example. Don't forget, however, it is also used very widely and commonly to remove the peels from delicate fruits and vegetables. In this case the fruits are totally immersed in steaming hot vats of the lye solution. In our process, however, the hot lye is sprayed on the surface of the grain for only a short time before it is washed away, together with the loosened bran.

The entire process is conducted as follows. Brown rice is first soaked in water that is gradually warmed to just below boiling. After transfer to a rotating drum, hot 2 to 5 percent lye is sprayed on and the tumbling continued for about 3 minutes. The now rather dark mass is dumped into water to remove the excess lye and to commence the washing. The grain is next passed through any one of several available devices in which it is subjected to an intense turbulence and whirling in the water. This removes the loosened bran and further washes the peeled kernels. They are then rinsed in dilute acid and moved along to a dryer to complete the process.

Among the questions that immediately arise in connection with this process are those of cost, yield, and quality. Preliminary estimates indicate that a cost of about 1 cent per pound of dry product is within expectation. So many factors affect costs that estimates at this early stage are very tenuous. We have had, however, two estimates from commercial sources of about 1.5 and about 2.1 cents per pound for the lye peeling of cooked wheat. Rice, however, is much simpler to peel--it requires much less caustic and does not need to be cooked; hence, less water, heat, and steam are required. The 1 cent per pound figure is fairly close to the normal milling costs for rice.

On the other hand, the yield of head rice by the lye-peeling process is higher than from the usual dry milling methods. The head yield promises to be very near to total yields; at least, they are in our small-scale equipment. This potential yield increase is perhaps the biggest single attraction to the new process.

The other major factor with which to evaluate preliminarily the possibilities of

the new process is the quality of the final product. One first notices that the color of the product is not as white as that of ordinary milled rice, nor are the surfaces of the kernels so smooth and shiny. Nevertheless, the product is surprisingly attractive, considering the type of processing involved. Very likely, the process will never be feasible for producing the glistening, high quality product that sells so well for table use in this country and in dollar markets abroad. On the other hand, the greater yield of only slightly lower quality product has several advantages for the overseas markets where rice is in such great demand and where price is of great concern. For one thing, the highly nutritious aleurone layer of cells remains on the kernel, as does the germ. The latter may mar the market appearance of fancy grades a bit but is well worth keeping for the hungry people overseas, especially the children. Retention of the aleurone layer is also necessary to avoid severe problems in the drying of the peeled grains. Very likely it also helps to minimize kernel breakage during the processing. This can be serious if checking during the initial soaking and heating is not carefully avoided.

This brings me to my second topic of discussion, because the slightly rough surface of the lye-peeled kernels permits the adherence of fortifying protein much better than regular polished rice. In fact, during the lye-peeling process enough extra protein can be added to more than double the total protein content of the final product. Think of what an advantage this could be for our Foods for Peace programs in the rice eating areas of the world.

You all know that rice protein is a very good protein nutritionally but that it is too low in amount for the grain to suffice by itself. By adding extra protein to the kernel without materially changing flavor, texture, or shape, this nutritional limitation can be overcome. Extra minerals and vitamins can also be added and can be fixed in place by suitable selection and treatment of the fortifying protein in the new patented development by Dr. Morgan and others at the Western Laboratory. The size of the potential market for this type of product is large enough so that the whole industry should get behind it and get the product moving into the hands of those who need it.

Another product for overseas marketing devolves from the high protein flours that can so simply be milled off the outer surfaces of normally milled rice. This is my third discussion topic. Dr. Deobald has already filled you in on much of the recent information on this product and its production. I now want to relate to you how it can be converted to beverage-type products for special but important uses. Most of you are familiar with the fact that a very common weaning food for babies in many rice-eating countries is a rice gruel. This is a natural choice because it is a bland, well accepted, easily prepared food. We have the bugaboo again, however, of not enough protein to meet the intended purpose. To put it mildly, the infants do not flourish on such a diet. By substituting a 15- to 20-percent protein rice flour for the regular rice, the problem could be greatly helped but not yet completely solved. The thickening power of the rice flour when made into a gruel is so great that, to be fluid enough for beverage purposes, the protein has to be diluted down so much that the infant has to drink a great deal more water than he should to get enough of the food elements he needs. Therefore, we have developed simple enzymatic processes whereby this thickening power of the starch is cut down sufficiently that gruels can be made as concentrated, yet as fluid, as milk. At the same time as the thickening power of the starch is being cut, we can also make the protein more soluble and easier to use. Again, other fortifying materials such as minerals and vitamins can be added easily and inexpensively. In fact, the flour itself is a rich source of several vitamins. Other sources of fortifying protein can also be used, if desired. Furthermore, the final product need not be a beverage similar to milk. It can as well be a soup, for example, flavored with fish, fowl, fruits, or whatever would be desirable in a particular country or district. The important thing is that improved nutrition can be offered in products and forms that are not strange or costly but rather are familiar and well suited to prevailing habits, traditions, and desires in every place of concern. The process has been patented by D. A. Fellers of our Cereals Laboratory. A preliminary cost estimate puts the cost of the product at about 11 to 12 cents per pound for a 6 cents per pound starting flour cost.

The high protein rice flours also might very well be used for the fortification of the

noodles or other flour-based products popular in the Orient and elsewhere. The familiar and essentially bland flavor of this modestly concentrated source of good protein makes it attractive for many food uses. As we all recognize, however, economics and availability factors will be unusually important for this particular product.

To take up, now, my fourth discussion topic, I want to come back to the domestic scene and to refer to the recent increases in per capita consumption of rice that have occurred over the past year or two. A variety of factors is undoubtedly involved in this very heartening upswing in consumption. However, I think we can assume not only that some people are eating more rice but also that a great many more people are eating rice for the first time. Some time ago I heard a speaker voice the opinion that many people were first attracted to the more frequent use of rice by the convenience of the precooked or quickcooking forms of rice that are now on the market. This would seem to be logical in the case of newlyweds, for example, and the many women who hold down a full-time job as well as keeping a household fed and operating smoothly. It seems to us that any and every improvement in convenience, quality, and cost of such products can only accelerate this wholesome trend.

Some of you are already familiar with the type of quickcooking rice that was developed at the Western Laboratory some time ago and is now used by a major national firm in its convenience, prepackaged rice products. Very recently, we have been working on a completely different and simpler type of processing to convert rice into a quickcooking product.

A novel feature of our new process developed by Huxsoll and Ferrel 1/ is the use of microwave energy to achieve the degree of starch gelatinization essential for a rapidly rehydrating convenience product. The raw rice is first soaked in water until it has reached a moisture content of about 35 percent. The moist grain is then passed through the microwave oven to cook it "from the inside out" in just a couple of minutes. As many of you know, this method of cooking has been rather expensive in the past; but with the larger and more efficient commercial units available today, the cost has come down considerably. With some applications, it is the best and least expensive way of conducting a cooking or drying operation to obtain the desired final product properties. The biggest such use of the equipment presently is in the manufacture of potato chips, a low cost product. In principle, the method makes use of a very rapidly reversing electromagnetic field which causes the individual molecules in the substance being cooked to oscillate violently enough that they generate their own cooking heat deep within the product--thus, the "inside-out" reference.

With some rices, a second soaking and cooking cycle is found necessary for best results, as is noted here. In either case, after sufficient cooking or starch gelatinization has been induced inside the kernel, the grain is again immersed in excess water to imbibe enough additional water (about 68-percent moisture) to be fairly equivalent to normal cooked rice. There remains a difference, however; the outer surfaces of the kernels are not overcooked and not so extremely sticky and loose as is usually the case with steam cooking. Therefore, the rice can now be dried in such a fashion as to leave whatever degree of porosity and fissuring is desired in the final dried form for quick rehydration with boiling water.

The process is attractive because washing and leaching losses of solids can be kept small. This also tends to help retain more of the original flavor of the rice and to make the final product texture very nearly like that of freshly cooked rice. Further, the avoidance of excessive gumminess and stickiness during processing will minimize mechanical losses due to clumping and the resultant breakage of the dry kernels when making them ready for packaging. The high cost of the microwave cooking should be well offset by such processing efficiencies. These aspects will be covered more completely in the technical publications that will be forthcoming shortly.

In the final segment of my paper, I want first to add to the comments that Dr. Deobald has made about the high-protein rice flours. Then I want to say a few things about rice proteins.

1/ Huxsoll, C. C., and Ferrel, R. E. Production of Precooked Rice. U.S. Patent Pending.

With our small pilot-scale CeCoCo mill, we have found that the deep-milling process works equally well with short-grain, medium-grain, and long-grain rices. It works well with waxy rice, and it works well with either low-protein or high-protein rices. In the latter regard, we tried it on a sample of rice having 12.4 percent initial protein. The sample was kindly supplied to us by B. O. Juliano of the International Rice Research Institute in the Philippines. The milling process also works well enough with second-heads rice. Yields are somewhat lower, but the lower cost of the starting material is a decided attraction.

One of the things we are particularly interested in with regard to these high protein fractions is how the individual proteins may be distributed among them, because we have learned that the various rice proteins differ considerably in their amino acid composition--hence in nutritive value. The method we are currently using to study the protein distribution in the flours is an adaptation of a method worked out by E. E. A. Maes 2/ in Belgium for the proteins in wheat flour. It is based on the consecutive extraction of different types of protein by means of percolation with a series of solvents--in our case water, aqueous alcohol, a lactic acid solution, and two concentrations of potassium hydroxide.

To date we have successfully worked out the various combinations of conditions necessary to apply the method to rice flour and have begun study of the protein profiles, you might say, of the collection of high protein and ordinary protein flours we have on hand. We will further study the composition of the various extracts by starch gel electrophoresis to identify the exact nature of the major components.

The proteins in rice have some rather novel features in comparison to other cereal proteins. The proteins in wheat, barley, and rye have many components and properties in common, but those from rice differ distinctly. For one thing, the quantity of water-soluble and alcohol-soluble proteins in rice is much lower. Correspondingly, rice contains much more of the type of protein requiring either acid or alkali for dissolving them. To date we have worked mostly with the globulin proteins. These are the ones that are soluble in water only if a certain amount of salt is first dissolved in the water.

Two types of globulins have so far been purified and studied in some detail. One is very high in the sulfur amino acids--nearly 4 percent of the weight of the dry protein is sulfur alone. We don't understand the significance of this peculiar facet of composition but are probing further, as we can. Another type of globulin protein in rice is very nearly devoid of the basic amino acids lysine and histidine, although it is rich in arginine. Here the low content of lysine is of particular concern because lysine is so frequently the first limiting essential amino acid in plant proteins, as it indeed is for rice. Other proteins in rice must be enough higher in lysine to compensate for this particular globulin, however, because rice is a little better off on the whole than is wheat or barley, for example. Thus, one can see a clear-cut reason, on practical grounds, to be concerned with protein component distribution in rice fractions for human foods.

Another reason we are interested in the protein components of rice and how they are distributed is that they appear to be related to cooking and probably other processing properties. Much of the variation in cooking properties among rice varieties has been traced to variations in proportions of amylose to amylopectin starch in the kernels. This has not been a completely satisfactory criterion, however. Dr. Deobald has already alluded to the fact that deep milling of rice causes a change in the cooking properties of the residual kernels. Dr. Golumbic will also probably have some additional remarks based on the work of Dr. Primo and others under their P. L. 480 grant.

Slowly but surely we all continue to build up knowledge of the fundamental characteristics of rice kernels and their constituents

2/ Maes, E. E. A. Progressive Extraction of Proteins. Nature 193: 880. 1962.

_____ Flour Protein Solubility and Baking Quality. III. Continuous, Progressive Extraction. Getreide and Mehl 12(6): 70–72. 1962.

_____ Protein Solubility and Baking Quality. Cereal Science Today 11: 200–202. 1966.

upon which to build ever-better products and processes. The sooner more such information is available, the easier will it be to adjust to the increasingly technical requirements of the food industries and the food products of the future. The conversion of cereal flours to milklike products such as I have mentioned today is but a forerunner of the kinds of food conversions, modifications, or restructuring that is just around the corner. The rice industry is little affected as yet, perhaps, but the need to prepare is plain. We hope we can continue to assist with the new opportunities as they come along so that the rice industry remains a dynamic and thriving industry.

DISCUSSION

Question: What becomes of the bran that is removed by lye?

J. W. Pence: It is lost. Almost all of the bran dissolves sufficiently in the alkali that it goes into the waste effluent.

Question: What is the extent of loss to the cooking water with quickcooking rice?

J. W. Pence: It is small. We do not have figures yet, but we believe it to be well under 5 percent.

Question: Is the oil in the bran saponified? Can it be recovered?

J. W. Pence: Surely some is saponified, but in any case the solutions are dilute enough that recovery would be difficult.

Question: Have you worked with whole grain fortification?

J. W. Pence: Yes, the fortification mixture is applied to the outside of the kernel and sticks well either to cracked or whole kernels.

Question: What proteins are used?

J. W. Pence: We have used soybean and fish protein preparations to date, but we believe that others can also be used.

Question: What is the cost of the quickcooking rice?

J. W. Pence: No estimates have been made yet, but we think the cost will be competitive with present methods.

RICE QUALITY RESEARCH IN SPAIN UNDER P.L. 480 PROGRAM

by
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A project was initiated in 1964 with the Departamento de Agroquimica y Tecnologia de Alimentos, Valencia, Spain, for studying the organoleptic, physicochemical, and biochemical changes in milled rice during storage. The study began under Andres Casas and is being continued by Salvador Barber under the direction of E. Primo.

Investigations have been divided into three areas: (1) Basic studies on the chemical composition of rice; (2) basic studies on aging of milled rice; and (3) basic studies on rice quality.

Basic Studies on the Chemical Composition of Rice

A study has been initiated on the -SH and -S-S- groups in rice, in order to obtain knowledge of the protein fraction of the cereal. SH groups, determined in nine rice varieties, have been found to vary from 2.01 to 1.00 microequivalent per gram (μeq./g.) rice and SS groups from 4.36 to 1.86 μeq./g. rice.

Information on the distribution of chemical constituents in the rice kernel and their characteristics was needed for basic studies

both on aging of milled rice and rice quality. For this purpose, the following studies have been initiated: (a) Distribution of starch constituents and (b) distribution of lipid fractions--neutral fats, free fatty acids, and phospholipids--and their fatty-acids composition. Although these studies are now in progress, preliminary data show qualitative and quantitative differences between successive layers of the kernel, which seem to be of basic interest.

Basic Studies on Aging of Milled Rice

In the storage program, laboratory-scale studies have been conducted on undermilled and white milled rice held at different conditions of temperature (-20°, +5 , and +25°C.), moisture contents (13.3 and 14.7 percent), and atmospheres (hermetic and aerated storage).

The effects of storage on the following characteristics or rice have been determined:

(a) Carbohydrates: Sugars (reducing and nonreducing), starch, amylose.

(b) Nitrogen compounds: Total nonprotein and protein nitrogen contents, total free amino acids, N index and sulfhydryl and disulfide groups contents.

(c) Lipids: Crude fat and fat acidity.

The simultaneous variations in organoleptic properties and physicochemical characteristics of rice have also been studied. In this connection, the changes in odor (appearance of off-flavors), cohesiveness, and overall acceptability have been subjectively evaluated. Changes in the following physicochemical characteristics have been determined: Water absorption at 70°C., loss of total, soluble, and insoluble solids during cooking at 70° C., gelatinization and pasting characteristics, pH and CO_2, O_2 and N_2 concentration in intergranular air.

Basic Studies on Rice Quality

Studies directed to determine the role played by major and minor constituents of rice in its processing and cooking behavior have been conducted along two lines of research:

(1) To obtain fundamental data on chemical composition of different rice varieties and correlate them with subjective measurements of rice quality; and

(2) To follow simultaneous changes during storage in composition or physicochemical properties and in organoleptic characteristics, and determine the existence or lack of correlation between both changes.

DISCUSSION

Question: What is the effect of moisture on mold growth during storage?

C. Golumbic: No such specific investigation was conducted.

Question: How would you distinguish between the terms, "market quality" and "preference" as used in your talk?

C. Golumbic: In the project, only the term, "preference", is used. This refers specifically to the results obtained by a trained taste panel.

Question: Are there any other P. L. 480 projects in the planning?

C. Golumbic: No.

Question: Why didn't the panel like undermilled rice?

C. Golumbic: I am not sure, but it is likely that off-odors and flavors would quickly develop in such rice during storage.

Question: How was cohesiveness determined in the sulfhydrye and desulfide containing amino acids investigation?

C. Golumbic: By subjective evaluation of the taste panel.

NEW RICE VARIETIES--THEIR COOKING AND PROCESSING CHARACTERISTICS [1/]

[Summary]
by
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The determination, as well as the evaluation, of the milling, cooking, and processing qualities of parental material, hybrid progeny, breeding lines, and new varieties of rice is an essential part of the coordinated rice breeding program conducted cooperatively by the U. S. Department of Agriculture and the agricultural experiment stations in the rice-producing States of Arkansas, California, Louisiana, Mississippi, and Texas. New varieties developed by rice breeders and released for commercial production must meet rigid and established standards for these qualities. Historically, certain cooking and processing qualities of rice are associated with specific grain types. For example, most of the long-grain varieties produced commercially in the United States cook dry and flaky and some are used for specific processed products. The short- and medium-grain varieties grown in the U. S. are more moist than the long-grain varieties when cooked, and are used for other types of prepared products. All grain types are in widespread demand, both for use as home-cooked table rice and various prepared rice products. It is extremely important that a new variety have the same or improved milling, cooking, and processing qualities as the variety it replaces. Now, in rice breeding programs, no new variety is seriously considered for release unless it does meet the quality standards required for its particular grain type. For the most part, the determination of these quality characteristics is carried out at the Regional Rice Quality Laboratory [2/]--first by evaluation of parental material quality, followed by evaluation of early generation progeny selections and continued evaluation through every stage of development leading up to the release of a new rice variety.

A number of new medium- and long-grain varieties of rice have been released for commercial production as a result of the cooperative rice breeding programs conducted in the various rice producing states. The recently released long-grain varieties are Bluebelle and Dawn. The new medium-grain varieties are Saturn and Nova 66. Detailed descriptions of the various characteristics--including yield, maturity, disease reaction, grain characters, milling, cooking, and processing qualities--of each of the new varieties as compared to those of leading commercial varieties, have been reported by Bollich and coworkers (3) on Bluebelle; Bollich and coworkers (2); Jodon and Sonnier (8); Johnston and coworkers (9); and Bowman (4) on Dawn; Jodon and Atkins (7) on Saturn; and Johnston and coworkers (10) on Nova 66.

The cooking and processing characteristics of the new long-grain varieties Bluebelle and Dawn are similar to those of Belle Patna and Bluebonnet 50, as determined from numerous evaluation tests conducted for several years at the Regional Rice Quality Laboratory by Bollich and others (2, 3). Similar studies by Jodon and Atkins (7) and Johnston and others (10) showed that the cooking and processing characteristics of the new medium-grain varieties Saturn and Nova 66 compare favorably with those of Nato. At the Rice Quality Laboratory, new and potentially new varieties of rice are

1/ Cooperative investigations, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture; Rice-Pasture Research and Extension Center of the Texas Agricultural Experiment Station, and the Texas Rice Improvement Association.

2/ The Regional Rice Quality Laboratory located at the Rice-Pasture Research and Extension Center, Beaumont, Tex. is operated by the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, in cooperation with the Texas Agricultural Experiment Station and the Texas Rice Improvement Association and serves the cooperative rice breeding programs conducted in Texas, Louisiana, Arkansas, Mississippi, and California. The program is also supported in part by grants-in-aid from Campbell Soup Company, New Jersey, and General Foods Corporation, New York.

routinely and systematically subjected to a series of chemical and physical tests which, collectively, serve as indices of specific cooking and processing behavior. The physicochemical properties of rice measured with these tests are used in characterizing the qualities of standard rice varieties of known cooking and processing behavior and this information, in turn, is used to describe the relative qualities of the new varieties of rice. The merit of characterizing rice cooking and processing characteristics in terms of specific physicochemical properties has been clearly demonstrated and has enabled rice breeders to develop and release new varieties combining desirable cooking and processing characteristics and agronomic features.

Routine characterization of specific cooking and processing characteristics of new varieties of rice consists of measurement of amylose content (15); starch-iodine-blue value (6); type and extent of disintegration of "head" rice in contact with dilute alkali (11); amylographic gelatinization and pasting characteristics (5, 14)[3/]; water-uptake capacity at 77°C. (5); crude protein (1); biuret protein (12, 13); and parboil-canning characteristics[3/].

Some comparative physicochemical characteristics of representative samples of the long-grain varieties Bluebelle, Dawn, Belle Patna, and Bluebonnet 50 and of the medium-grain varieties Saturn, Nova 66, and Nato from the 1963 and 1964 crops grown in the Uniform Rice Performance Nurseries in Arkansas, Louisiana, and Texas are summarized in table 1. The data show that the long-grain varieties usually react similarly--and that the medium-grain varieties usually react similarly--when samples from the same season and location are compared. However, and as expected, differences are obtained from different seasons and locations. The results of these and other comparative evaluation tests indicate that Bluebelle and Dawn have the desired cooking and processing characteristics required for long-grain uses, and that Saturn and Nova 66 are satisfactory for medium-grain uses. In addition to laboratory evaluation tests, samples of the new long- and medium-grain varieties were sent to leading commercial processors of rice and rice-containing foods for evaluation. The results obtained from these processors have also indicated that the cooking and processing qualities of the new varieties are satisfactory and compare well with those of leading commercial varieties of rice.

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3/ Webb, B. D. 1962. Method of objectively evaluating the parboil-canning characteristics of rice varieties. [Unpublished data] Annual Report.

Table 1.--Comparative physicochemical characteristics of new and other varieties of rice grown in the uniform rice performance nurseries at Beaumont, Tex.; Crowley, La.; and Stuttgart, Ark., in 1963 and 1964 1/

Variety and location	Milled rice (moisture content = 11.5 percent)							Parboiled rice
					Amylograph-viscosity			
	Amylose content	Starch-iodine-blue value	Alkali reaction	Water uptake at 77°C.	Peak	After 10 min. at 95°C.	Crude protein (Nx5.95)	Parboil-canning dry matter (solids) loss
	Percent	Percent tr.	Av. No.	No.	Brabender units	Brabender units	Percent	Percent
Long-grain varieties:								
Dawn								
Beaumont	25.2	14	3.3	120	765	405	5.9	20
Crowley	25.8	16	3.6	123	845	440	5.9	21
Stuttgart	25.5	12	4.4	120	690	400	6.7	21
3-location av.	25.5	14	3.8	121	767	415	6.2	21
Bluebelle								
Beaumont	24.4	15	3.2	124	855	455	6.3	18
Crowley	22.7	15	3.1	134	890	455	7.0	18
Stuttgart	25.2	14	4.9	148	745	390	7.5	19
3-location av.	24.1	15	3.7	135	830	433	6.9	18
Belle Patna								
Beaumont	23.3	14	3.5	133	865	415	6.5	18
Crowley	23.2	14	2.7	133	880	420	6.7	19
Stuttgart	24.8	14	3.4	144	740	395	7.7	19
3-location av.	23.8	14	3.2	137	828	410	7.0	19
Bluebonnet 50								
Beaumont	23.2	17	3.3	141	860	420	6.7	21
Crowley	22.2	18	3.7	164	845	405	6.1	20
Stuttgart	24.9	14	4.5	153	785	405	6.4	20
3-location av.	23.4	16	3.8	153	830	410	6.4	20
Medium-grain varieties:								
Saturn								
Beaumont	13.2	56	6.0	300	1025	410	6.6	32
Crowley	15.4	56	6.2	375	1060	460	5.8	32
Stuttgart	16.5	50	6.4	312	900	380	7.0	33
3-location av.	15.0	54	6.2	322	995	417	6.5	32
Nova 66								
Beaumont	14.4	54	6.0	326	985	385	6.4	37
Crowley	16.3	53	6.2	354	1045	430	6.0	36
Stuttgart	17.6	43	6.6	374	895	360	6.7	34
3-location av.	16.1	50	6.3	351	975	392	6.4	36
Nato								
Beaumont	13.7	60	6.0	315	920	390	6.4	34
Crowley	15.7	64	6.0	388	995	440	6.6	32
Stuttgart	17.4	52	6.9	369	895	385	7.3	35
3-location av.	15.6	59	6.3	357	937	405	6.8	34

1/ Results of tests conducted at the Regional Rice Quality Laboratory, Beaumont, Tex. Data taken from Bollich and others (2) and Johnston and others (9, 10.)

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CAPABILITIES AT THE SOUTHERN UTILIZATION RESEARCH AND DEVELOPMENT DIVISION FOR RICE RESEARCH

by
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(Presented by C. H. Fisher)

This discussion, as suggested by the title, is concerned primarily with the research capabilities of the Southern Utilization Research and Development Division (SURDD), including both total capabilities and those used in rice research. The discussion follows the outline:

Total research capabilities in SURDD.
Research capabilities in SURDD for rice.
Total U. S. capabilities for rice research.
Relationship of research inputs to outputs.
How much effort should be invested in research?
Rice research recommended by advisory groups.
Value and importance of rice.
Research needs and opportunities.

TOTAL RESEARCH CAPABILITIES IN SURDD

Research Facilities. Most of the facilities (about 90 pct.) of the SURDD exist in the Southern Regional Research Laboratory (SRRL) in New Orleans. The New Orleans facilities will be increased soon by the construction of a new building consisting of about 30,000 sq. ft. Present SRRL facilities include:

About 460 employees (both technical and nontechnical).
Four floors with total floor space of 175,000 sq. ft.
One hundred and twenty individual laboratories.
Library with more than 28,000 volumes.
Large pilot-plant areas for both chemical engineering and textile engineering investigations.
Budget of about $7 million per year.

Four following smaller laboratories at other locations report to the SRRL. They are the Fruit and Vegetable Products Laboratory (20 employees) Winter Haven, Fla.; Naval Stores Laboratory (23 employees), Olustee, Fla.; Southcentral Fruit and Vegetable Products Laboratory (10 employees), Weslaco, Tex.; and Food Fermentation Laboratory (6 employees), Raleigh, N. C.

The SURDD, composed of the laboratories mentioned above, has a total of about 525 employees.

Because the SURDD conducts chemical, processing, and utilization research, most

of the technical employees are chemists, physicists, chemical engineers, mechanical engineers, textile engineers, microbiologists, and mathematicians.

The funds allocated to SURDD in fiscal year 1965 were about one-fourth the total USDA budget for utilization research and development, namely, $29,885,000 (8).

As shown in tables 1 and 2, about 60 pct. of the SURDD facilities are used for research on cotton. About 1 pct. of the total effort (about 3 professional man-years) is devoted to rice research.

Table 1.--Funds for research and development (R&D) in SURDD 1/

Commodity	Thousand dollars fiscal year 1965	1966
Rice	79.1	72.3
Cotton	4,447.5	4,632.2
Fruits and vegetables	939.8	977.2
Cottonseed, peanuts, tung	1,510.8	1,576.4 2/
Sugars, naval stores, new crops	701.5	408.7 2/
Total	7,678.8	7,666.8

1/ From USDA, ARS Project Breakdown, 1965 and 1966 (9)

2/ Research on tung, sugarcane, and new crops terminated June 1965.

A total of 316 men work on cotton, compared with a total of 5 who work on rice. About 60 pct. of the total SURDD staff is professional or technical.

Research Program.--As indicated by Table 2, about 65 pct. of the total intramural effort is invested in research on the industrial crops, cotton, and naval stores. About 35 pct. of the total effort is concerned with food and feed products. The crops receiving most attention are cotton lint or fiber (60 pct.); cottonseed (14 pct.); and citrus fruits (9 pct.).

The research of the SURDD is conducted in two pioneering research laboratories, eight commodity laboratories, and one functional laboratory as shown below:

Organization of SURDD for Research

Pioneering Research Laboratories (to acquire basic knowledge):

Plant Fibers (C. M. Conrad, Chief Research Chemist)
Seed Protein (A. M. Altschul, Chief Research Chemist)

Commodity Laboratories (to develop knowledge, products, and processes of practical value):

Cotton Chemical Reactions (J. D. Guthrie, Chief)
Cotton Finishes (W. A. Reeves, Chief)

Table 2.--SURDD program by commodities in FY 1966 1/

Item	Total man-years 2/	Percent of total effort
Industrial (64.9 pct.):		
Cotton	316	60.0
Naval Stores	25	4.9
Food and Feed (35.1 pct.):		
Cottonseed	72	13.7
Peanuts	34	6.5
Citrus and other fruits	46	8.7
Vegetables	24	4.6
Sugars and sirups	3	0.6
Rice	5	1.0
Total	525	

1/ Intramural program. Research on sugarcane, tung, and new crops terminated June 1965.

2/ About 60 pct. of the total staff is technical.

Cotton Mechanical (R. A. Rusca, Chief)
Cotton Physical Properties (R. T. O'Connor, Chief)
Food Crops (V. H. McFarlane, Chief) 1/
Fruits and Vegetables (M. K. Veldhuis, Chief) 2/
Naval Stores (R. V. Lawrence, Chief) 3/
Oilseed Crops (L. A. Goldblatt, Chief)

Functional Laboratory (cost, engineering and pilot-plant investigations):

Engineering and Development (H. L. E. Vix, Chief)

The principal responsibility of the two pioneering laboratories is to acquire new fundamental knowledge through highly creative and pioneering research. The principal responsibility of the eight commodity laboratories is to develop new information, products and processes of practical value. The functional laboratory (Engineering and Development), concerned with all the commodities of the SURDD, conducts cost and feasibility studies, carries out operations on a pilot-plant scale, and conducts engineering and pilot-plant studies as needed to assist in the commercialization of research developments.

With the exception of the two pioneering laboratories, the Laboratories have three to six groups each called Investigations under the leadership of a specialist in the field. The Investigations usually have about 10 employees each.

The program is greatly aided by cooperation with various industrial, educational, and other organizations. Although most of the cooperation is informal, some of it is documented and supported by funds or research fellows provided by industry associations. Currently, support to the extent of 10 research fellows (or their equivalent in funds) is being provided by the Foundation for Cotton Research and Education; National Cotton Council of America; National Cotton Batting Institute; Textile Waste Association; National Cottonseed Products Association; Florida Citrus Commission; National Confectioners' Association; National Pickle Packers' Association; Pan American Tung Research and Development League; Pulp Chemicals Association; International Lead Zinc Research Organization; and Cane Sugar Refining Research Project, Inc.

The SURDD assists in the planning and review of agricultural utilization research conducted in foreign countries with Public Law 480 funds.

Research Administration

Management of the Division and program coordination at the Division level are performed by the Director, four Assistant Directors, an Assistant to the Director for Administrative and Plant Management, and their staffs:

G. E. Goheen, Assistant Director for Program Operations
C. L. Hoffpauir, Assistant Director for Program Development
R. M. Persell, Assistant Director for Program Appraisal
B. H. Wojcik, Assistant Director for Industrial Development
G. P. Clasen, Assistant to Director, Administrative and Plant Management

Dissemination of Research Information

More than 3,500 publications and 400 patents have resulted from R&D in the SURDD. The following statistics for fiscal years 1961-65 illustrate how research information is made available:

	1961	1962	1963	1964	1965
Patents	16	24	25	13	24
Technical publications	172	196	183	188	191
Speeches, press releases, radio, TV	132	204	268	169	250
Formal conferences with industry	7	29	17	21	17
Public service exhibits	6	6	16	11	12
Visitors with technical interest	1,162	1,287	883	2,275	2,554

1/ The laboratories at Weslaco, Tex. and Raleigh, N. C., are a part of and report to the Food Crops Laboratory.
2/ Winter Haven, Fla.
3/ Olustee, Fla.

A list of publications and patents (with abstracts) is published twice each year. These are available on request at no cost.

Close collaboration is maintained with USDA's Federal Extension Service (FES) as another means of disseminating research information. At present two FES representatives assist in maintaining technical liaison with processors, State and Federal Extension workers, and other groups to expedite adoption of new products, processes and equipment. These FES employees give specialized assistance in the fields of cotton products, processing and equipment.

RESEARCH CAPABILITIES IN SURDD FOR RICE

As already indicated, about 1 percent ($72,300) of the total SURDD effort is devoted to rice research. This means that funds for rice research and development will support no more than about three professional man-years.

Most of the SURDD rice research is done in the Rice and Sweetpotato Investigations (H. J. Deobald, Head), which is a part of the Food Crops Laboratory (V. H. McFarlane, Chief).

Other members of the Food Crops Laboratory engaged in rice research are: J. T. Hogan, F. L. Normand, and N. R. Bertoniere.

Limited work on rice is done intermittently in the Food Products Investigations (J. J. Spadaro, Head) of the Engineering and Development Laboratory (H. L. E. Vix, Chief).

The experts, special instruments, and facilities used in SURDD research on cotton, cottonseed, peanuts, and others (99 pct. of the Division's total effort) are available for rice research to a reasonable degree where there is a special need. For example, several years ago, our cotton mechanical engineers designed, constructed, and operated new equipment needed for the deepmilling of rice on a pilot-plant scale. At present, some of our food technologists in the Engineering and Development Laboratory are doing exploratory work on expanded rice products.

The volume of rice research in USDA's Western Utilization Research and Development Division is similar to that in SURDD.

TOTAL U. S. CAPABILITIES FOR RICE RESEARCH

Total effort on rice research in the United States is estimated at about 19.3 professional man-years by USDA; 15.6 by State Agricultural Experiment Stations; and an undetermined amount by industry--estimated in 1962 at about 100 professional man-years. The industrial research is performed primarily by chemical and fertilizer firms on agronomic aspects; millers and other processors of food products on work of a trouble-shooting nature: and farm equipment and facility manufacturers on the development of equipment for planting, cultivating, harvesting, handling, and storing of grain products. Total U. S. utilization research on rice is estimated at about 19 professional man-years.

Table 3. --Rice Research in the United States
[Professional Man-Years]

Agency and type of research	Total Research 1962 1/ Man-years	1963 2/ Man-years	1964 2/ Man-years	1965 2/ Man-years
USDA				
Farm research	14	11.7	10.2	10.2
Utilization research	6	7.5	6.7	5.6
Marketing and economics	8	6.5	3.0	3.5
Total	28	25.7	19.9	19.3
AES	17	-	13.2	15.6
Industry	100	-	-	-
	145			

1/ "Summary of Current Program and Preliminary Report of Progress – Rice," U.S. Department of Agriculture, December 1962.

2/ "Summary of Current Program and Preliminary Report of Progress – Grain and Forage Crops," U.S. Department of Agriculture, December 1963, 1964, and 1965, respectively.

From the estimates given above, it may be concluded that a total of approximately $4 million annually in the United States is invested in rice research. This sum ($4 million) is about 0.4 pct. of the retail value of ($1 billion) of rice and about 1 pct. of the farm value ($400 million).

RELATIONSHIP OF RESEARCH INPUTS TO OUTPUTS

As an approximation, it can be said that research outputs are directly proportional to the inputs, that is, the quality and volume of effort invested in the research.

Because the SURDD has acquired the services of excellent scientists, engineers, and excellent physical facilities, the quality factor in SURDD research is high and relatively constant. Consequently, the research output depends primarily on the quantity of the input. This reasonable conclusion is supported by the facts. More specifically, SURDD research outputs (as measured by publications, patents, commercialized developments and awards) for cotton greatly exceed the outputs for rice research (table 4).

However, considerable variation exists in the level of research effort between commodities and areas within commodities because of limited resources. Hence, the research effort has been directed where potential results appear greatest.

HOW MUCH EFFORT SHOULD BE INVESTED IN RESEARCH?

A great deal has been written and said on this subject.

Enthusiasm for and understanding of research profitability differ among various groups and individuals. Some industries, that is, chemical and pharmaceutical, give strong support to research, whereas others give little or negligible support (table 5).

Table 4. --Nature and value of research results, SURDD, Fiscal years 1963-65 [1/]

Item	Papers		Patents		Developments [2/]		Awards	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Southern Division	558	100	63	100	42	100	15	100
Cotton	275	49	39	62	21	50	9	60
Cottonseed	57	10	11	17	8	19	2	13
Rice	7	1	0	0	0	0	0	0

1/ Percent of total research effort: Cotton, 60 pct.; cottonseed, 14 pct.; and rice, 1 pct.
2/ Commercialized developments resulting from or significantly aided by research of the SURDD.

Yale Brozen has reported that profits in industry are directly proportional to the funds invested in research (table 5).

The following paragraphs do not attempt to answer the question about the wise and proper support of research. Instead, they

Table 5. --R&D investment as percent of sales and rate of return on net assets for leading corporations (5,000 or more employees) [1/] [2/]

Industry	R&D investment, pct. of sales			Return on net assets (pct.)
	1964	1961	1953	1954
Aircraft and parts	33.1	26.0	9.2	27.4
Instruments	6.7	6.6	5.3	16.8
Electrical equipment	7.3	5.6	6.6	15.4
Chemical	3.5	3.9	2.8	14.5
Machinery	3.0	3.6	2.2	11.7
Motor vehicle and transportation	3.0	2.6	---	----
Rubber	1.4	1.5	1.1	12.1
Stone, clay, and glass	1.1	1.1	---	----
Petroleum	.87	1.0	.7	13.8
Fabricated metal	.67	.59	.8	11.0
Paper	.50	.45	---	----
Food	.21	.19	.1	10.5

1/ Data for 1961 from Yale Brozen (2).
2/ Yale Brozen (1).

provide additional information about how much research is invested in various enterprises and commodities.

Industrial and Federal Research

The R&D effort of the Nation as a whole amounts to about $23 billion, or about 3 pct. of the Gross National Product (GNP). The Federal Government pays for about 70 pct. of the total.

Financial support for R&D has grown rapidly over the past two or three decades (table 6). For the period 1940-63, Federal expenditures for R&D increased at the average rate of 19.8 pct. per year. R&D is now a major industry in the United States (table 6).

The nature and extent of this research revolution may be illustrated by comparing the period immediately before 1940 with the period of 1940-63. Federal funds for R&D zoomed to record highs following 1940, the Federal budget for R&D in 1963 being about 167-fold greater than that of 1940. Funds for defense research increased about 270-fold and funds for space research increased about 1,000-fold. During the same period, Federal funds for agricultural research increased about six-fold. (Because of inflation the increases in manpower did not equal the increases in dollars.)

Agricultural Research

The Departments concerned with agriculture, natural resources, and commerce

Table 6. -- Some recent trends (percentages and costs ($billion)) in R&D in the United States 1/

Agency and type of support	1960 Expenditure	1960 Pct.	1960 Pct. of GNP	1963 Expenditure	1963 Pct.	1963 Pct. of GNP	1966 Expenditure	1966 Pct.	1966 Pct. of GNP
R&D and plant, total	$12.9	100	2.6	$19.7	100	3.4	$24.0	100	3.4
Federal obligations	8.1	63	1.6	13.7	70	2.3	16.1	67	2.3
Industrial support	4.5	35	.9	5.6	28	1.0	7.3	30	1.0
Universities support	.3	2	---	.4	2	---	.6	3	---
Federal obligations:									
Research	2.0	15	.4	4.1	21	.7	5.6	23	.8
Development	5.6	43	1.1	8.4	43	1.4	9.7	40	1.4
Industry performance:									
Research	2.4	19	---	3.0	15	---	---	--	---
Development	8.1	63	---	9.7	49	---	---	--	---
Total	10.5	82	---	12.7	64	---	15.2	63	---

1/ From (6).

2/ Includes R&D plant facilities.

As already indicated (table 5), the total R&D effort is not spread evenly over the various industries. Several industries spend 4 pct. or more of their sales on research, whereas some spend less than 1 pct. for this purpose.

Revolution in Federal R&D

World War II brought a revolution in Federal R&D and radically altered research emphasis and the relative position of agricultural research.

received increased funds for research but at lower rates. For example, the Department of Agriculture received 39 pct. of the Federal R&D dollar in 1940 and occupied the number one position with respect to share of the total research budget. In 1963 the Department of Agriculture received about 1.4 pct. of the Federal R&D dollar and dropped in rank from position one to five (table 7).

It has been reported that funds for agricultural research in 1964 were spent as

Table 7. --Federal expenditures for research and development in fiscal years 1940 and 1963 [1/]

Agency	Million dollars		Increase (fold)	Percent of total		Rank	
	1940	1963	1940-63	1940	1963	1940	1963
Total, all agencies	74.1	12,334	167	-	-	-	-
Dept. of Defense	26.4	7,170	270	35.6	58.1	2	1
NASA[2/]	2.2	2,397	1,090	3.0	19.4	6	2
AEC	-	1,438	-	-	11.7	-	3
HEW [3/]	2.8	677	240	3.8	5.5	5	4
USDA	29.1	175.6	6	39.3	1.4	1	5

1/ From (6).

2/ National Advisory Committee for Aeronautics before FY 1958.

3/ Federal Security Agency before FY 1952.

follows: Federal, $228 million; States, $140 million; and industrial, $400 million. The total ($768 million) was about 2 and 0.76 percent respectively, of the farm and retail values of the farm products (4).

RICE RESEARCH RECOMMENDED BY ADVISORY GROUPS

Various committees and groups have recommended research programs on rice. These recommended programs have not been fully implemented because of insufficient facilities.

The President's Commission on Increased Industrial Use of Agricultural Products, with the aid of 18 different task groups (including one on rice), studied research needs and presented a detailed report in 1957 (10).

The Rice Task Group, which advised the Commission, had the following members: Marshall Leahy, Cochairman; W.M. Reid, Cochairman; A.M. Altschul; L.C. Carter; R.E. Derby; W.J. Duffy, Jr.; J.P. Gaines; G.R. Harris; B.C. Hammer; George Kohler; and L.A. Villeret.

This group, after making a comprehensive study, recommended a greatly expanded (several fold) program of rice utilization research. An abbreviated account of the recommendations of the Rice Task Group was included in the Commission's report (10, pp. 30, 117, 118). The Commission, without mentioning individual commodities recommended more than a threefold increase in utilization research.

In response to Senate Resolution 415, 87th Congress, Second Session, October 13, 1962, the Agricultural Research Service of USDA studied the needs and opportunities of utilization research and reported the conclusions in Senate Document No. 34 (11). This report recommended that the total USDA utilization research program of $24 million be increased to $59 million per year. The recommendation for an increased program included rice research.

In 1965, the Rice Millers' Association (represented by J.P. Gaines, Executive Vice President) presented a proposed rice research program before the Agricultural Subcommittee of the Senate Committee on Appropriations (5). Mr. Gaines' statement reviewed progress in rice research, spelled out additional needs for research, recommended expansion of the program, and pointed out that various USDA Advisory Committees have supported rice utilization research.

Committees advising on research consider the pertinent facts and estimates, which include those concerned with volume, value, and importance of the commodity in question; potential markets and profits; availability of promising research projects; and the like. Research is usually recommended where: The commodity is large, valuable, and important; potential markets are large; profits (assuming the research is successful) are estimated to be high; research projects and approaches seem promising; and required research facilities are--or can be made--available.

VALUE AND IMPORTANCE OF RICE

Rice, Aristocrat of the Cereals, is a Major U. S. Crop.

Annual production in the U. S. is about 7 billion pounds and increasing. The annual values at the farm and retail levels are estimated to be almost $400 million and $1 billion, respectively (3).

Rice compares favorably in importance with wheat. Although U. S. wheat acreage was 27 times greater than rice acreage in 1964, the farm value of the wheat was only five times that of rice 1/.

Production and value of rice in the U. S. have been increasing, whereas these figures for U. S. wheat have decreased in recent years. During the period 1960-64 both the farm value and production of wheat in the U. S. decreased (farm value from $2.37 billion to $1.77 billion).

During the same period U. S. rice production increased 34 pct. and the farm value increased from $248 million to $361 million (45 pct.). For rice during the period of 1949-64, the following approximately doubled: Production (from 4.1 to 7.3 billion pounds), yield per acre (from 2.2 to 4.1 thousand pounds), and farm value (from $167 to $361 million).

Further information on rice and wheat are given below (table 8).

As indicated below, the yields of protein, starch, and oil for U. S. rice per acre (1965 average) are greater than the corresponding yields for wheat:

	Rice	Wheat
	Lb. per acre	Lb. per acre
Kernels (bran removed)	3,050	1,372
Bran	468	242
Oil	67	27
Protein	264	211
Lysine	8.9	6.3
Starch	2,010	646
Hulls	772	0
Straw (dry)	5,150	3,067

U. S. rice yields in 1965 ranged from 3,650 lb. of rough rice per acre in Louisiana to 4,800 lb. in California. Wheat yields ranged from 18 bushels in South Dakota to 54 in Nevada.

Rice is Important Internationally

Annual world production of 568 billion pounds (table 8) is worth more than $16 billion and earns about $900 million in foreign trade.

For the majority of the world's exploding population, rice is the most important food and cereal crop. For each increase in population of 100 million the world will need an

Table 8.--Production and value of rice and wheat in the U. S. and the world, selected years

Item	Unit	United States				World			
		Rice		Wheat		Rice		Wheat	
		10-season average 1953-54 through 1962-63	1963-64 season	10-year average 1954-63	1964	5-season average 1958-59 through 1962-63	1963-64 season	5-season average 1958-59 through 1962-63	1963-64 season
Production	million tons	2.8	3.7	33.8	38.7	262	284	276	275
Acres	millions	1.7	1.8	49	49	296	311	505	514
Value	billion $	.27	.36	2.1	1.7	14.0	16.6	18.7	19
Consumption	million tons	1.3	1.5	14.5	15	--	--	--	--
Yield	lb. per acre	3,300	4,096	1,378	1,578	1,767	1,830	1,093	1,080
Protein	lb. per acre	203	252	165.6	189.6	108.7	112.5	131.3	129.8

1/ Senti, F. R. Review of USDA research on cereals. See pages 48 to 52 of this Proceedings.

additional 13 million tons of grain. It is estimated that an annual increase in rice production of more than 2.5 pct. will be required to meet the needs of the growing rice-eating population.

Rice has grown steadily in economic importance in the U.S. and the world. Projections suggest that this growth will continue at a more rapid rate than wheat cereals. A comparison of the phenomenal growth of rice is shown in figures 1 and 2.

Potential Domestic Markets are Large and Growing

As shown below, the U.S. per capita consumption of grains is much higher than that (7.6 lb. a year) for rice. Comparison of the per capita consumption of rice with that for total food consumption in the U.S. (1,500 lb. annually) gives further evidence that there is room for expansion of domestic rice consumption (table 9).

Potential markets for rice in the feed and industrial areas also are important. The principal rice byproducts (straw, bran, and hulls) are inexpensive enough for either feed or industrial uses but improved methods for transforming these materials into useful feeds and industrial products are needed.

Rice kernels and starch are admittedly too expensive for most feed and industrial purposes. However, additional production and processing research should lower costs. In addition, the manufacture of protein-rich flour from broken rice kernels (of suitable grade) should yield a starch-rich residue inexpensive enough for some industrial uses.

Export Markets for Rice are Large and Growing

Export markets are particularly attractive because they are already tremendous and are growing rapidly.

Unless population trends change markedly in the next 35 years, there will be more than 6 billion people on earth at the beginning of the new century. This will represent an increase in population of about 3 billion. Unless dietary habits change radically, most of these people will eat more rice than any other food and will live in the rice belt, which cuts a curving swath across the globe from West Pakistan to Japan. Today, more than 90 pct.

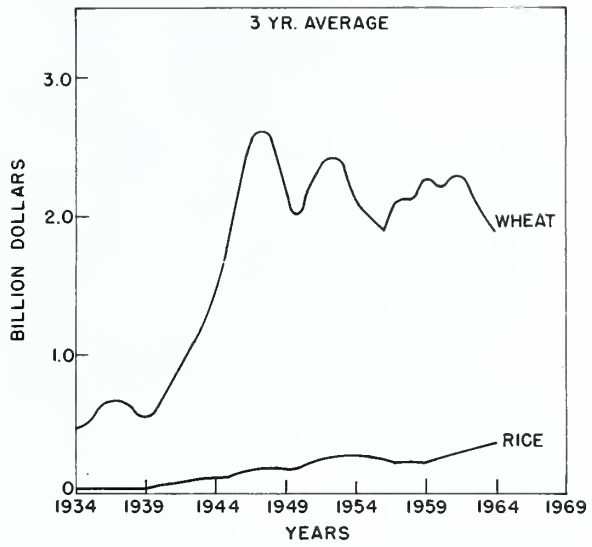

Figure 1.—Farm value of U.S. wheat and rice.

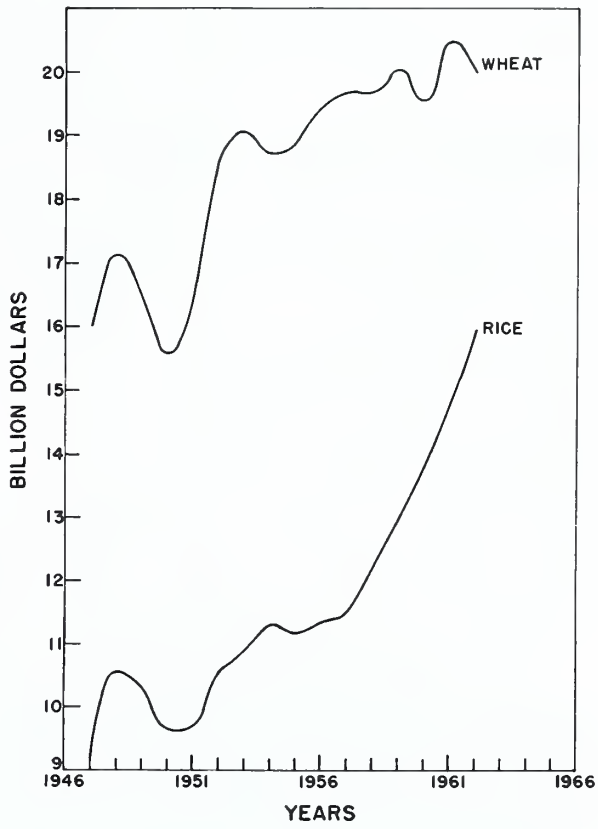

Figure 2.—World value of wheat and rice.

Table 9. --Annual per capita civilian consumption of grains as foods 1/

Year	Wheat flour and cereal	Rye flour	Rice	Corn-meal and cereal	Corn-starch	Corn Syrup	Oats	Barley
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
1949	139.2	1.5	5.0	14.2	1.8	8.6	3.3	1.5
1964	118.6	1.1	7.6	8.6	1.8	13.5	3.5	1.0

1/ From U.S. Dept. Agr. Agricultural Statistics 1965 (12, p. 53).

of the billion and a half inhabitants of Asia, whose members are increasing by nearly a million a week, subsist mainly on rice, and around 80 pct. of them spend nearly all their time growing and distributing enough of it to keep them alive. Quite a few of them are barely able to manage that (7).

World rice production is almost 100 times U. S. rice production. Hence, U. S. rice exports could be doubled or tripled without disturbing international rice trade. In fact, the export market is so large that it can readily absorb all the rice that can be produced in the U. S. Over the past few years U. S. rice exports for dollars have grown from 7.2 million cwt. (1960) to 16.0 million cwt. (1964).

Uniqueness of Rice Offers Utilization Possibilities

No other starch granule is so uniformly small as that of rice; no other cereal shows such variation in the amylose-amylopectin ratio of its starch (gel controlling components); no other cereal decreases as much in value with kernel breakage; no other cereal changes in properties with age as does rice; no other cereal grain is generally so hard and vitreous; no other seed exhibits the intense lipolytic activity characteristics of rice bran; and the nitrogenous constituents of rice differ in amount and properties from those of other cereals.

RESEARCH NEEDS AND OPPORTUNITIES

Advisory groups have considered both industry problems and research opportunities and have recommended research to solve the former and to exploit the latter.

Rice Industry Problems

The principal problems involved in the processing and utilization of rice are listed below.

Kernel Breakage During Processing. --Kernel breakage during processing is a serious industry problem that is responsible for economic losses of about 1/2 cents per lb. and $35 million annually.

Limitations in Cooking Qualities Cause Economic Losses to the Rice Industry. --It is necessary to grow short-grain rice to obtain the type of cooked rice (gelatinous masses) wanted by some consumers. Conversely, long-grain rice must be used to provide the cooked rice (discrete kernels) wanted by other consumers. Because long-grain rice costs about 15 pct. more than short-grain rice, economic consequences are major, amounting to about $10 million annually.

Low Protein and Vitamin Contents of Rice Present a Problem. --In a world that is becoming increasingly aware of the need for good nutrition, the nutritive inadequacies of rice (based on low protein and vitamin contents) are becoming more of a handicap.

Health Hazards Have Presented a Problem. --Although the problem of toxic molds seems less serious for rice than for some other crops, there is always the possibility that molds will cause trouble. Research has been done on several other farm products to avoid or minimize the hazards of mold toxins and radioactive stronthium-90. Such research may be needed for rice.

Rice Manufacturing, Merchandizing, and Research Handicapped by Lack of Adequate Evaluation Methods. --There is the need to develop improved objective and accurate methods for measuring quality (flavor components, composition, physical properties, etc.).

The Rice Industry Is Handicapped by a Paucity of Processed Products. --Some competing foods are available in a variety of attractive forms. Additional attractive rice products are needed to overcome this disadvantage.

Dearth of Fundamental Information on Rice. --The dearth of fundamental information on rice is a problem because this handicaps the limited research being done to help rice.

Research Opportunities

The utilization research projects recommended by various groups and individuals may be categorized as follows under the two main headings, Principal product (rice kernels), and Byproducts:

I. Principal product (rice kernels)

A. Process development: Decreased kernel breakage; processing to avoid health hazards (radioactivity and mold toxins); bran removal by chemical and enzymic methods; freshly harvested rice; and methods for transforming any type of rice (long-, medium-, or short-grain) into cooked products of any desired firmness, texture, and viscosity.

B. Product development: High-protein rice flour; new products from deepmilled rice kernels (including broken kernels); stable and attractive brown rice products; products partly suitable for export markets; improved quick-cooking rices; and fortified rices.

C. Cooperative research with other research organizations.

D. Development of objective evaluation methods: Physical properties; properties of aqueous and other dispersions; chemical properties; degree or extent of ageing; cooking characteristics; etc.

E. Fundamental research: Short-range, that is, in support of research having direct practical objectives, and long range, such as chemical; physical; and microscopical.

II. Byproducts

A. Straw and hulls: Feeds by ammoniation, hydrolysis, or fermentation; industrial products such as panel boards, drilling muds, plastic foams; and dextrose and furfural. Bran: stabilized foods and feeds, rice oil, and specialty products based on composition and properties. Wax specialty products, such as polishes and rust inhibitors.

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SECOND SESSION: V. H. McFarlane, Chairman 1/

THE NUTRITIONAL VALUE OF RICE

by
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Rice has been the staple cereal food of more than half of the world's people for thousands of years. Rice is not a completely adequate food from a nutritional standpoint, nor can this be said of any other single food. In general, cereals have less nutritional value than animal foods such as milk, meat, and eggs. Rice is among the best of the cereals in many respects as will be discussed later.

It is important to consider the nutritional quality of foods, not just the number of calories they provide, but also the protein, mineral, and vitamin content. One of the most significant problems in the world today is protein-calorie malnutrition. Perhaps half of the world does not get enough food to satisfy energy requirements. In all of the developing countries large segments of the population receive too little protein. The groups that suffer the most are infants after weaning and preschool children. The importance and prevalence of protein-calorie malnutrition has been recognized by many national and international organizations, and numerous programs are underway to help meet nurtitional needs in various parts of the world. The world food problem is considered one of high priority by President Johnson and many U. S. agencies, including the Departments of Agriculture, State, and Health, Education, and Welfare; the Agency for International Development; and the Food for Peace Program. The rapidly increasing world population and the necessity of adequately feeding these multitudes of people must be foremost on the agenda of all policy planning groups.

Rice is important in this overall program since it is used by millions. Let us consider its nutritional value. Rice is about 80 percent carbohydrate and less than 0. 5 percent fat. Raw white rice furnishes 6. 7 percent protein, whereas brown rice furnishes 7. 5 percent. How good is rice protein? Can rice alone fulfill the protein requirements of man? The answer is no, not without other supplementary foods being included in the diet. The Recommended Dietary Allowance for protein for adults in the United States is 1 gram per kilogram of body weight per day. It would be necessary to eat about 1, 000

1/ Southern Utilization Research and Development Division.

grams of rice (raw weight) daily which would amount to about 15 or 20 cups of cooked rice. This is double the consumption of persons who live on high rice diets; that is, diets in which rice furnishes about 80 percent of the calories.

Protein requirements cannot be discussed solely in terms of quantity; quality of the protein must also be considered. Protein must furnish all of the essential amino acids which the body cannot manufacture. There are eight of these for adults and nine for infants. These amino acids must be supplied not only in proper amounts but in correct balance one to the other. The protein of food must also be digested and absorbed from the intestinal tract. In addition, it is necessary to supply sufficient calories from carbohydrate and fat so that protein will be spared for more important uses in the body. A number of the vitamins and minerals must be present also for adequate utilization of protein and other energy foods.

The quality of dietary protein can be evaluated in several ways. In animal studies, the protein efficiency ratio (PER) is determined. This is the weight gain of the growing animal divided by the protein intake when calories are adequate. The PER for milled rice is 1.5 to 2.0 percent at protein levels that are obtainable with this cereal. Another method of evaluating protein quality is to determine net protein utilization. This includes estimation of digestibility and of the biological value of absorbed protein. The biological value of protein is dependent on its amino acid content. The perfect protein would have a value of 100; that is, 100 grams of this protein could be used to form 100 grams of tissue protein. The biological value of protein depends on the amino acid pattern. The efficiency of utilization depends on the quality and also conditions under which the protein is eaten. A diet that provides less than 5 percent of the total calories in the form of utilizable protein cannot meet adult needs.

Protein can be evaluated by its chemical score; namely, the degree to which its content of essential amino acids fulfills some provisional, desirable pattern. Such a pattern was formulated by the Food and Agriculture Organization (FAO) of the United Nations in 1957. More recently, an expert group convened by FAO and World Health Organization (WHO) reconsidered all aspects of protein requirements and proposed that the pattern of essential amino acids in whole egg was the most acceptable and practical standard of reference for protein evaluation. Table 1 shows the chemical scores of selected proteins using three different reference standards, the FAO pattern, human milk, and egg protein. It can be seen that the score for rice is about 75 when compared with egg or human milk and 70 when compared with the FAO pattern. The most limiting amino acid is lysine. The net protein utilization (NPU) of rice is 57 compared to 100 for egg protein, but it is higher than that for certain other foods shown in the table.

Proteins can be described in another way--by determining the ratio of total essential amino acids to total nitrogen (E/T ratio). In table 2, the E/T ratio is given for several protein sources. The importance of nonessential nitrogen in assisting in fulfilling protein needs has been emphasized recently, and hence this ratio is of importance.

The value of protein can also be expressed as the proportion of individual essential amino acids to total essential amino acids or the A/E ratio as shown in table 3. This ratio indicates the amino acids that are present in the least amounts and which limit the biological value of the protein to the greatest extent. In comparing the essential amino acid pattern of rice with that of hen's egg, it is obvious that the most limiting amino acid is lysine. In addition, isoleucine, threonine, tryptophan, and the sulfur-containing amino acids are somewhat low. Supplementation of rice with lysine would improve the quality of the protein. Since most rice diets are supplemented with some other protein foods, persons receiving such diets are supplied with protein of moderately good quality.

The vitamin and mineral content of rice (table 4) should also be discussed. Rice contains no fat soluble vitamins and no ascorbic acid, and accordingly other foods must be included in the diet to supply these substances or deficiency will occur. Milled white rice is very low in thiamine and riboflavin, and in rice-eating areas of the world the most common deficiency disease is beriberi, which is due to thiamine deficiency. In these areas, riboflavin deficiency may also occur unless supplementary foods high in this vitamin are ingested. The niacin content of rice is resonably good, and hence pellagra is uncommon among rice-eating population groups.

Table 1. --Variations in chemical scores of selected protein using different reference standards

Food	Based on FAO provisional pattern	Based on human milk essential amino acid pattern	Based on egg essential amino acid pattern	Limiting amino acid egg pattern	Net protein utilization
Milk (cow's)	80	75	60	S	75
Egg	100	90	100	-	100
Rice	70	75	75	Lysine	57
Cornmeal	40	40	45	Tryptophan	55
White flour	50	50	50	Lysine	52
Cottonseed meal	70	95	80	S	66
Peas	60	70	60	S	44
Cassava	20	50	40	S	--

Table 2. --Ratio of total essential amino acids to total nitrogen

Protein source	E/T ratio
	g./g.
Egg, hens	3.22
Milk, cows	3.20
Cornmeal	2.78
Rice	2.61
White wheat flour	2.02
1957 FAO pattern	2.02

Table 3. --Essential amino acid patterns

Amino Acid	A/E ratio: mg./g. of total essential amino acids	
	Hen's egg (whole)	Rice
Isoleucine	129	119*
Leucine	172	215
Lysine	125	100**
Total "aromatic" amino acids	195	243
Phenylalanine	114	117
Tyrosine	81	116
Total sulfur-containing amino acids	107	88*
Cystine	46	44
Methionine	61	34
Threonine	99	99
Tryptophan	31	27*
Valine	141	177

Table 4. --Nutrient content of rice--100 g. cooked (approximately 1/2 cup)

	Unenriched	Enriched
Calories	109	--
Protein, g.	2.0	--
Fat, g.	.1	--
Carbohydrate, g.	24.2	--
Calcium, mg.	10.0	--
Iron, mg.	.2	.9
Vitamin A, I.U.	.0	--
Thiamine, mg.	.02	.11
Riboflavin, mg.	.01	.36+
Niacin, mg.	.4	1.0
Ascorbic acid, mg.	.0	--

The thiamine content of rice can be improved by undermilling or parboiling; and these methods, as well as enrichment with thiamine, have been used in the prevention of beriberi.

DISCUSSION

Question: Are proteins studied from animal feeding studies?

G. A. Goldsmith: Yes.

Question: What values do you use yourself?

G. A. Goldsmith: I prefer the FAO egg protein standard. It is in excess of the minimum; however, it is still superior to the arbitrary FAO standard previously set up.

ENRICHMENT OF RICE

by
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Rahway, N.J.

This morning Dr. Fisher mentioned this is International Rice Year and that 1966 is the 25th Anniversary of the Southern Regional Research Laboratory. I'd like you also to be aware that this year, the enrichment program is celebrating its 25th anniversary and certainly you of the rice industry are to be congratulated for your participation in these programs. During this last 25 years, the vitamin deficiency diseases of beriberi and pellagra have almost disappeared in the United States, and the voluntary decision by rice millers to enrich some or all of their products is at least partly responsible for the disappearance of these deficiency diseases.

Why do we enrich and what is it? Enrichment may be considered as a restoration of vitamins and minerals lost during milling. The milling process removes about 70 to 90 percent of the natural thiamine, 56 percent of the riboflavin, 65 percent of the niacin, 85 percent of the fat, 90 percent of the calcium, 60 percent of the pantothenic acid, and 55 percent of the pyridoxine from stock commonly called brown, or whole, or unmilled rice. If the whole rice is parboiled before milling, most of the naturally occurring vitamins and minerals are retained. However, the parboiling process is not inexpensive. In fact, if the only objective is to market enriched rice, then parboiling is probably a rather expensive way to go about it. I don't know much about the cost of parboiling, but I can point out that costs of about 3.0 cents per hundred pounds are necessary to break even with a straightforward milling and enrichment process. Of course, there undoubtedly are other sound reasons for marketing parboiled rice so my head-on comparison may be unfair.

Generally speaking, the simplest and least expensive method of enriching rice is that of a powder enrichment. A mixture of vitamins and iron with a suitable excipient or carrier (usually rice starch) is fed into the stream of rice issuing from the milling machines. The usual rate of addition is 1 pound of enrichment mixture to 3,000 pounds or 6,000 pounds of rice. Rice thus enriched and packaged for sale usually bears the warning "Do not wash before cooking, and so forth". The added powdered enrichment increases the content of thiamine, niacin, and iron, and some mills add riboflavin, up to the levels required by the U.S. Standards of Identity for Enriched Rice. Parboiled rice is also supplemented with small amounts of vitamins and iron if it is to conform to the Standards of Identity for Enriched Rice.

When rice is sold in bulk in cotton or jute bags, it very likely will be washed before cooking. Under these circumstances, a powder enrichment would be lost in the rinse water. There are two possible solutions to this problem. One is to add enrichment in the form of a readily dispersible wafer to the water at the time the rice is cooked. This technique was used successfully by the Chinese Nationalist Army on Formosa before an enrichment premix was available. A second technique which prevents the loss of added vitamins in rinse water is to add a "rice premix." This form of enrichment may be defined as addition in the mill of rice grains carrying such high levels of the enrichment vitamins and iron that, when blended into highly polished rice, the resulting blend supplies the minimum levels of these nutrients as required by the Standards. Commercially available "rice premixes" are produced by coating or impregnating rice kernels with vitamins and iron and protecting these added nutrients against washing losses by covering them with a water-insoluble coating. Such "rice premixes" are usually added at the rate of 1 pound per 200 pounds of polished rice.

At the present time, the rice industry requires probably more than 20 formula variations to accomplish enrichment objectives. I would ask you to compare the variety of enrichment formulations your industry requires to the wheat flour milling industry where two formulae are sufficient, and to the baking industry which uses two formulations, and to the corn millers whose needs are satisfied by three formula variations.

The fragmentation of the total market for enrichment in the rice industry into relatively small amounts of several formulations does result in increased costs over comparable mixtures marketed to the flour, corn, or baking industries whose mixtures can be produced in much larger quantity units. I believe that several of the rice enrichment formulations produced could be telescoped into one or two mixtures, probably to your economic advantage.

Let's briefly take a look at the status of the enrichment programs since the initial laws were passed 25 years ago.

According to estimates that are generally held today, approximately 50 percent of all of the packaged rice on the shelves of supermarkets in the U. S. is enriched. This can be compared to estimates that about 75 percent of the packaged cornmeal is enriched, as is about 80 percent of all the bread and rolls, and almost 100 percent of the all-purpose family wheat flour. Wheat flour, bread, and cornmeal are enriched with thiamine, riboflavin, niacin, and iron, while much of the rice enriched for domestic markets does not contain added amounts of riboflavin. However, the tonnage of enriched rice which includes riboflavin is increasing steadily.

As you know, the mandatory addition of this vitamin was stayed in 1958 following objections to its use by some of the rice millers. Objections were filed on the basis that yellow riboflavin imparts an offensive yellow color to the enriched rice. Yet, Dr. Lease of Clemson University packaged rice in transparent bags that was enriched with and without riboflavin, and he then placed these packages side by side in supermarkets in South Carolina. The consumer showed no preference for the enriched rice without riboflavin. This market test can be interpreted to indicate that in one of our major rice eating states the slight yellow cast imparted to rice by enrichment levels of riboflavin is unimportant to the consumer. I'm sure that marketing personnel associated with each rice mill marketing consumer packages are thoroughly familiar with competitive packages, so it can be no secret that some mills are enriching with thiamine, niacin, iron, and riboflavin. It seems, then, that the consumer is not sufficiently concerned about rice color so that she is persuaded away from brands containing riboflavin. The "stayed" status of riboflavin in the Federal Standards for Enriched Rice implies that a final decision is yet to be reached. Therefore, I pose this question, "Is the status of riboflavin in the Standards for Enriched Rice satisfactory, or now that 8 years have gone by, should riboflavin achieve the stature of a mandatory--or an optional ingredient?" I anticipate that rice for foreign donation programs will soon be enriched and there can be little doubt that this enrichment should include riboflavin--and, perhaps, additional vitamins as well.

This morning Drs. Deobald and Pence spoke of new milling techniques. We are concerned that the surface of rice milled by one or more of the new processes will have different characteristics from rice produced by current milling techniques that may effect the uniform distribution of powder enrichment ingredients. Therefore, attempts are being made in our laboratories to pretreat the surface of milled rice so that vitamins and iron can stick tight, and overall distribution of enrichment ingredients will be improved regardless of the milling techniques used. The technique we are studying has not yet been tested commercially and it is difficult from lab runs to evaluate all the problems that may be encountered, or even that the economics may be favorable or unfavorable. However, we have demonstrated that uniform distribution of powdered enrichment can be attained by pretreatment of the rice kernel and extensive shipping and shake tests indicate the enrichment ingredients adhere tenaciously. Our pretreatment test materials are limited to those for which Food Additive Regulations have been written, but the Standards of Identity for Enriched Rice would probably have to be amended to permit the use of such materials. These comments are premature, I know, but my purpose in mentioning this is to (1) let you know that our laboratories are continuing to work on rice enrichment problems; (2) we will probably be asking some of you to help us evaluate the economics of the process in the relatively near future; and (3) should chemical milling become a method of choice, we would hope to be ready with workable answers to potential enrichment problems.

DISCUSSION

Question: What are the prospects for the development of a nonyellow riboflavin?

P. A. Hammes: Poor, the compound is simply yellow.

Question: Do you use a new process to get an even coating?

P. A. Hammes: No.

Question: What about the other B vitamins? Have you made any effort to add these?

P. A. Hammes: Vitamin B_6 may be put in. I don't know about the others.

Question: Would a water-insoluble coating affect cooking quality?

P. A. Hammes: No, heat breaks these coatings down.

Question: What disease does riboflavin combat?

P. A. Hammes: Ariboflavinosis.

THE HANDLING OF RICE

by
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It is a pleasure, indeed, to appear before such an important group as this, and I hope that my remarks will be informative and lead in some small way to better handling procedures and methods for the rice industry.

We have seen many changes and improvements in the last 25 years. The most drastic was the introduction of the combine and the necessity of controlled drying. It is here that we find our first area in need of research. Our procedures today have been mostly developed in the field by trial and error. Sometimes we stumble on better methods and find that ideas commonly accepted to be true are not necessarily so.

How much moisture should be removed on the first drying? How should we determine the best temperature to use? Should this be based on outside air temperature, temperature of rice coming from drier, or is there a better way? What should be the minimum and maximum time between drying? How many times should we dry? What temperatures should be used each time, and how much moisture should be removed? What is the effect of relative humidity on the best drying procedures? What percent of moisture provides best and safest storage conditions, while at the same time develops the best milling characteristics? You can see that we have a multitude of variables, and a commercial operator never has time or space to explore all the possibilities.

Each year we find the farmer demanding better and quicker unloading facilities at the driers. He does not want his trucks wasting time in long lines. As he equips himself better for faster cutting and larger loads, he taxes the driers' handling methods and procedures to the fullest. If the weather is good, the entire rice crop can be harvested in an amazingly short period of time. How do we dry rice quicker but not sacrifice quality and milling yield?

We have experimented in a limited way with a jet stream conveyor. It seems to have unlimited possibilities. If you are not familiar with the jet stream, it is a conveyor which uses a supply of air to lift the material and give it direction. The supply of air can be controlled, if desired, for either heating or cooling. The jet stream principles of air flow are ideal for most effective heat transfer. Drying time can be reduced to a fraction of that of other methods; and the material is being conveyed at the same time. One of these conveyors, in connection with a turning leg or receiving leg, should greatly increase the efficiency of a drier. We do not know whether or not they would be practical for moving the volume necessary to move during harvest. Would ambient air be satisfactory, or would changeable weather conditions make controlled air necessary? Perhaps a refrigeration unit here, to reduce temperatures rapidly after drying, would be beneficial. I understand that they can even be used to replace conventional driers. These conveyors

are completely self-cleaning, and therefore very desirable from a mixing or sanitation viewpoint. I think the rice industry has need for this type of system, and urge that consideration be given to its many possible applications.

Very little rough rice is handled in bags, so the problems of handling it center on methods of unloading cars and trucks and on conveying and distribution systems. Unloading methods vary from hand shovels to power scoops, screw conveyors, pneumatic conveyors, and power lifts. A recent USDA Research Report found a variation from 10.1 man hours per 1,000 cwt. of rough rice down to 3.7 man hours between the systems. Selecting the best system, therefore, depending on volume and speed requirements, is a very important economic factor.

There is a definite trend toward greater movement in hopper cars. Most users are in position to handle hoppers, and the main limitation is availability of the equipment.

Since all rough rice is handled and stored in bulk, it is commonly transferred to the milling operation by belt or screw conveyors, and lifted where necessary by bucket elevators. The method of handling, after milling, varies considerably, depending on the size of the operation. The same USDA Research Report found--to move 1,000 cwt. of rice--a difference of: from 11 man hours to as many as 52 man hours to move the same quantity. Systems studied covered bagging all rice and the use of hand trucks through partial bagging, fork lifts, and on to total bulk handling. Rapidly increasing labor costs and ever higher bag costs are making bulk handling even more attractive. Pressure from Food and Drug Inspectors is on all food handlers, and their attitude toward rodents and infestation is forcing the rice industry to take a hard look at its material handling methods.

Bulk handling has its problems, too. Some of these can best be solved by research, others by trial and error, and some by upgrading personnel training. Some problems can be relieved by changes in grade standards, improvement of facilities, and perhaps even rice varieties.

Let's take a look at some of these problems. A good system allows for speedily handling large volumes without breakage or mixing. It is easy to keep clean, and when necessary the grain can be fumigated. Blending of rice from all bins is accurate and easy. After proper blending, the material can be loaded in bulk hoppers, box cars, trucks, or can be sent to bagging scales. No unblending or quality changes can be permitted in these areas.

The most economical construction of milled rice bins would appear to be large, deep concrete construction. But these type bins, if too large, can result in breakage of kernels--especially long grain varieties--and any lot that might be overly tender or checked. Any breakage is costly, since whole kernels have a value of 3 to 6 cents a pound more than broken kernels. An extremely small quantity of chits will cause down-grading of quality, and therefore is also very objectionable. Another case against big and deep bins is the amount of coring or unmixing that occurs when the bins are emptied. Broken kernels work their way toward the edges, and the last rice discharged will contain much more than the average. Economical and efficient methods of controlling breakage and unmixing in these type of bins are needed. For proper varietal purity and insect control, it is also necessary that there be no places where the rice can hang up.

Modern-day bulk handling requires tremendous speeds. Bins must be constructed to aid this, but even more important are the distribution systems to and away from the bins. These problems vary with the user. The rice miller has several products: Whole grains, secondheads, screenings possibly, and brewers. To add to his problem, he must segregate varieties, qualities, and degrees of milling, including brown rice. Mixtures of any of these are expensive, to say the least, and more than likely, disastrous.

The distribution systems must handle quickly and easily these many items. Breakage here is also important, as well as ease of changing bins and fool-proofing mixups. The old time systems were dotted generously with cushion boxes. True, they held down breakage, but were made-to-order for insect build up in nonmoving stock. Pure food attention has resulted in changing them into types of self-cleaning boxes, or other type systems. Belts are fine. They prevent breakage, are self-cleaning, and move rice

quickly. However, they are somewhat restrictive in close areas, and choice of discharge areas can be limited.

Many modern plants are using pneumatic conveyors. Breakage, here, can be the main problem, although ease of unloading cars and operation seem to offset this problem. These systems seem to be desired by firms unloading many different products into the same elevator. They eliminate the need for pits under hopper cars, and when designed and operated properly have been quite successful.

Because of the nature of rice sales and grading standards, the handling of milled rice in bulk is more complicated than many other grains.

Some method of blending lots from various bins under very controlled conditions is necessary. Since all rice going into the elevator must go through this blending system, it must work speedily and be easily changeable from one blend to another. Distribution must be made to areas of packaging, bagging, or into bulk cars. For the above types of distribution and blending, one must go high again and once more encounter dangers of breaking. High speed elevators can also be hard on tender kernels. Discharge from one system into both hoppers and box cars also presents problems. Open car doors make flying insect control a problem, and the weather is a real hazard without suitable cover.

Practically all other grains are moved in bulk, and it's evident from RMA records that an ever growing amount of rice is headed this way.

Our biggest industrial users--cereal manufacturers, breweries, and others, further processing, reprocessors have been taking top quality rice in box and hopper cars. The trend is definitely toward hoppers, and our more progressive railroads are providing more and bigger hoppers each year. They are easy to load, clean and sanitary, easy to unload, easy to fumigate, seldom leak, and carry fantastic loads. Four thousand cubic foot cars are readily available, and usually provide cheaper rates when loaded to capacity.

Ever increasing amounts of brown rice, for further processing, are being exported through New Orleans, Houston, Beaumont, Lake Charles, and Mobile. There have been many problems, but mostly these are ones of timing and equipment. Because most port elevators are very busy handling other types of grain and meal, an order for 1,000, 2,000, or even 5,000 tons of brown rice is not particularly attractive. Elevators can make money blending these other products, but on rice they do not have this opportunity. The elevators must be cleaned especially well, and this is difficult when they were not designed for this type of cleaning. Most port elevators have big bins, as well as distribution systems, that can break rice. The cars of rice can be blended from one shipper for one order; but, because of grades, varieties, and out-turn yields, further blending is not permitted. The house must be recleaned for each group or time of unloading and shipping.

Because of these problems, most rice has to be transferred direct from cars into ships. Large volume, therefore, favors volume shippers. At best, steamship schedules can be very aggravating. They are always late, or early, and usually opposite of your wishes. Proper timing is required to prepare and load brown rice just in time to allow transporting or switching to bulk-loading facilities, without catching demurrage one place or the other. These problems are being met, however, and more interest is being observed for better port elevator systems. They are needed badly.

We have just recently seen a reduction in "Free Time" at the ports. The acute car shortage is critical, and we'll probably see even higher charges for demurrage. It takes some time to accumulate a cargo, and when ships are delayed unreasonably the resulting demurrage can be very serious. The answer lies in facilities equipped to handle rice in bulk and provide adequate storage for accumulating quantities.

Bulk loading from cars or trucks into barges and then to ships by clam shells have also been accomplished. Although not explored to the fullest, good possibility lies in this area, particularly if floating legs were available and weight requirements could be satisfied.

A close examination of current rate structures clearly points out the advantage of bulk handling. Let's look at New Orleans, for example, from handling of rice in Arkansas to its destination in Europe:

	Bags	In bulk
Printed burlap-del'd. plant	$0.243	$0.
Labor cost, over bulk	.015	0.
Unloading and tollage	.077	0.
	.335	0.
Handling bulk		.065
Ocean freight	.876	.491
	$1.211	$ .556

From this point on, we do not have cost figures, but the savings are already $0.655 per cwt. Since this rice is to be remilled, it is probably handled in bulk, at least until it is milled.

With ever-increasing port and bagging costs, our most productive fields should lie in the exportation of bulk milled rice. No. 5/20 rice moves at times in big volumes. Some blending at elevators would be permissible because a grade of U.S. No. 5 is standard responsibility for guaranteeing outturn broken content, so important for subsidy, would be necessary.

Proper cleaning of steamships and insect control presents a major problem, but not an unsurmountable one. Bulk P.L. 480 sales would reduce dollar cost, as the bags and bagging would be accomplished with the buyer's currency.

One of the biggest problems to date on bulk exports has been the carrier's reluctance to pay claims on scale variances, and the railroads have refused where hoppers were concerned. Detailed studies through different ports is enough to "drive you crazy." Incidentally, this problem is not peculiar to rice but also meal and other grains. Subsidy benefits have also been curtailed in some instances. Each weight seems to be less, and then the buyer complains at destination. Where does it go?

Most port facilities are open to the weather. The Janapese have raised questions in regard to the effects of weather on the grains: "Could they breathe properly?" and "Would the sun shining through the large holds check the kernels while being loaded?"

The Japanese have also raised doubts about the keeping qualities of bulk brown rice during a long voyage and in hot weather. There is also confusion in regard to whether scuffing of the outer bran layers is helpful, or harmful.

I would also like to mention another handling problem that affects the rice milling industry. More and more pressure is building up from chain stores, warehouses, and even the Military for palletized shipments. There are savings for everyone, but initial costs of pallets--either returnable or disposable--have to be met. Suitable methods of loading trucks to capacity--and cars--without strapping or repalletizing must be found. I don't believe anyone has come up with a workable system, yet; but the problem is here and we, as an Industry, should reach a solution.

In summing up, I feel that the rice industry could profit by research into the following areas:

1. Drying methods and procedures.
2. Causes of bin breakage to milled rice, and methods of control.
3. Ways of preventing unmixing of blends.
4. Types of facilities and handling systems needed to meet present and future needs for bulk loading at port.
5. Effects of exposure and storage of brown rice on milling characteristics and taste.
6. How the industry can meet demands for palletized shipments.

May I repeat that it is a pleasure to be here, and I thank you for this opportunity to discuss our problems.

DISCUSSION

Question: How does the jet stream compare with the screw conveyor?

W. L. Knoll: They are about the same.

Question: What is the maximum capacity of the jet stream?

W. L. Knoll: I don't know.

Question: Does the jet stream knock the hull off of rough rice?

W. L. Knoll: No.

Question: Did you dry in passes?

W. L. Knoll: No; we used this machine as a conveyor and to extract surface moisture only.

Question: Did it break the kernels?

W. L. Knoll: No.

Question: What angles can be used? Can it be used in a vertical position?

W. L. Knoll: No, but it can be put on an incline.

Question: What is your power requirement?

W. L. Knoll: I don't know, but I can look it up.

CONVENTIONAL MILLING OF RICE

by
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Kaplan, La.

To you who are gathered here, I am supposed to speak of the subject pertaining to the conventional milling of rice. For this endeavor, I was allocated some 20 minutes of this program.

By paying more than competing mills for the farmers' paddy and then selling the finished or milled products cheaper than his brother millers are quoting qualify one to be a conventional miller of rice. These certainly are the qualifications of a bonafide Louisiana rice miller.

Now, that I've stated it so briefly, I do not know what to do with the remaining time allotted to me, unless I dwell a little on how the rice was milled prior to the bankruptcy proceedings.

The first rice mills involved the use of mortar and pestle for removing the chaff or husk, and some of the bran. The degree of milling depended on the pressure created by the pestle and the duration of the process. Winnowing removed the chaff and bran.

The February 1966 issue of the "Rice Journal" gives an account of a mill of this type located here in New Orleans in 1728 and states that both mortar and pestle were carved out of black gum wood and depended on hand operation. This same principle was later mechanized by use of windmills and perhaps water wheels to actuate the pestle, which was raised and lowered in the mortar containing the rice.

European culture and progress later devised the sequence milling of rice. The hulls were first removed by a pair of circular stones, one rotating and the other stationary or fixed. The planes of surface of these stones were horizontal and parallel to each other and their distances apart depended on the grain length of the rice. The revolving stone imparted tangential motion to the paddy and in tumbling the husk would become nicked on its way to the outer periphery. Only the ends of the husk were nicked and the brown rice with its chaff, along with short unhulled paddy flowed from the stones. As the apartness of the stones were set for some 95 percent effectiveness in husk removal, a good many of the longer than average grains were broken in the process and the shorter grains were unhulled.

The product of the stones was then subjected to aspiration whereby the husks or chaff was removed, leaving only the brown rice and unhulled paddy.

For efficiency in milling, all the product from the stones (excluding chaff) is run through paddy machines which are reciprocating, compartmented, specific gravity machines working on the flotation principle. The heavy shelled brown rice being removed at one elevation and the lighter paddy at a higher elevation. The paddy or unhusked rice missed by the primary stones then repeats the cycle through a secondary stone commonly termed a return stone.

You will note that both the past and present tenses are being used. The past tense is used to describe outmoded machinery while the present tense indicates machinery still being used.

The brown rice was then run through pearling cones or whiteners for bran removal, these machines being used in series for progressive bran removal. The machines were inverted cone frustums surfaced with an abrasive cement of carborundum or emery and when rotated would impart circular motion to the rice. This motion being arrested at intervals around the encased periphery by rubber brakes or baffles with the resulting scouring off of the bran layers by the abrasive cone surface. Raising or lowering the cone in a parallel conical enclosure determined the milling degree on the rice.

In the United States, the cone-type machines gave way to the Engleberg coffee huller about 1915 to 1920 period. This was done partly because less maintenance was required, but mostly because of the small differential existing at that time in prices of whole grain and broken rice. European milling has not discarded the cone-type mill.

These Englebergs, or coffee hullers, imparted circular motion along with linear motion to the rice through use of vanes and fins on a rotating metal cylinder confined in a perforated metal lining. Through friction of grain upon grain, and a calcium carbonate additive, the bran was scoured off. The degree of milling depended on retardation of the output and also on the depth of a blade arresting the circular motion of the rice. Because of its ability to also shell or hull the rice, a mill's capacity was greatly increased as dependency on the paddy separators was not as strict as with the cones which do not shell the rice.

Because of the frictional heat generated, the Englebergs or hullers were not efficient. Considerable broken rice resulted. I might add that USDA standards of yields are yet based on this type of milling. The heat generated by these machines caused a waxing or caking condition and continuous surveillance was mandatory.

Sometime soon after World War II, the Japanese introduced an improved machine working on the same principle. This machine propels a blast of cooling air through its rotating cylinder and the rice. The cylinder and rice are encased in a hexagonal liner with upset perforations like a kitchen food grater. It uses a weighted discharge gate to control the degree of milling and this input is forced through by a worm screw as in a meat grinder. As the heat generated is carried off by the cooling air, there is no wax buildup, and a minimum amount of attention is necessary while an improvement in outturn results. The use of calcium carbonate is also an aid to these machines.

The Japanese also introduced the rubber rice shellers or dehuskers at the same time the pearlers were introduced. This machine is superior to the stone sheller, as its principle of dehusking is based on grain diameter instead of length to husk the rice. This results in less broken rice. Basically, this machine consists of two parallel and horizontally mounted counter-rotating rubber cylinders revolving at different speeds and contacting each other at the 3 and 9 o'clock positions. The degree of contact or pressure between the cylinders is regulated by a compression spring in the old types, and by air pressure in the new types. The differences in their peripheral speed plus the pressure exerted by the rubber cylinders cause the paddy to be both squeezed and rolled, resulting in its dehusking.

Today, one in rice milling circles speaks of a modern mill as having the Japanese type shellers and pearlers. However, quite a few mills have variations and combinations of all types heretofore mentioned.

I might mention that to further the head rice outturn, a wet milling process is being used and while it is supposed to be "hush hush," I think I can tell you something about it. The brown rice in a hexane slurry is scoured in a closed system of pearlers, the miscella is fractionated, and the oil and bran separated in a solvent recovery plant similar to other oil seed types.

Then, too, there is the parboiling and milling of rice that encompasses a thousand other headaches along with those of white milled rice.

A conventional rice miller has the burden of financing the necessary inventories, he must manipulate and juggle trust receipts, use bills of lading, or anything resembling

collateral. In other words, he must be sufficiently dexterious to make "Vishnu" the Hindu god of many arms seem like a piker.

He must see to it that his mill removes objectionable seed and trash from the rice, that proper grain length separations are made, and also that power is transmitted correctly.

Storage, sales, shipping, packaging, sanitation, and other numerous factors must be dealt with on a day-to-day basis.

Scanning the present rice milling operations, it is my opinion that we have achieved the maximum insofar as milling yields are concerned, except perhaps milling under controlled conditions of temperature and humidity. There is, in my opinion, a great deal to be accomplished in the drying of rice under controlled conditions to alleviate the internal grain stresses caused by shock heating and cooling as a result of crowding capacity during the harvest period.

QUALITY CONTROL PROBLEMS RELATING TO RICE

by
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A meaningful discussion of quality control in rice requires that all participants have in mind the same definition of quality. Perhaps the word "definition" should be amended by adding the adjective "limited." Certainly, the word "quality" can have many different connotations.

In my discussion, quality is first limited by the area of responsibility of our agency and that area is "the maintenance and improvement of quality during post-harvest handling, conditioning, and storage." I am placing a second arbitrary limit on quality in this paper, one dictated by my primary work responsibilities--the association between microbiological activity and quality. These two limitations would appear to so restrict the definition that the subject should be easy to discuss. However, a little reflection shows that they have not limited the definition, but have only restricted the area in which we work to that part of rice production starting with the harvest and ending with processing. We must still be concerned with such different aspects of quality as: Milling quality, cooking quality, consumer acceptance, and nutritive value. All of these different facets of quality in rice can be affected by microbiological activity. Assuredly, there are many interrelations among these various kinds of quality but I will discuss each one in relation to the effects of microbiological activity according to my own arbitrary limits.

Seed pathologists generally classify the mycoflora of seed into two broad categories: (1) Field fungi--those species that infect the seed prior to harvest. They are generally parasitic or semiparasitic. The most common genera associated with rice are Helminthosporium, Nigrospora, Fusarium, Curvularia, and Alternaria. (2) Storage fungi, consisting primarily of species of the genera Aspergillus and Penicillium that rarely invade seed until after it is harvested.

The micoflora of a given lot of rice may therefore consist of field molds or storage molds or any combination of the two groups. The prevalence of groups or species at a given time is the cumulative result of the lot's entire history but reflects most strongly the effects of inoculum levels, available moisture, and temperature. Hence, there is ordinarily a continuous change in the specific makeup of the fungal flora that reflects the ability of species to compete under a given set of environmental conditions. This is illustrated in fig. 1 which shows the changing prevalence of field fungi in respect to that of storage fungi in a lot of rice dried in a commercial type drier. Note that field fungi decrease as storage fungi increase and that the rate of change is accelerated by the pass through the drier but continues at a slower rate during tempering and/or storage (4).

How does fungal activity affect quality? Let us first look at effects on milling quality

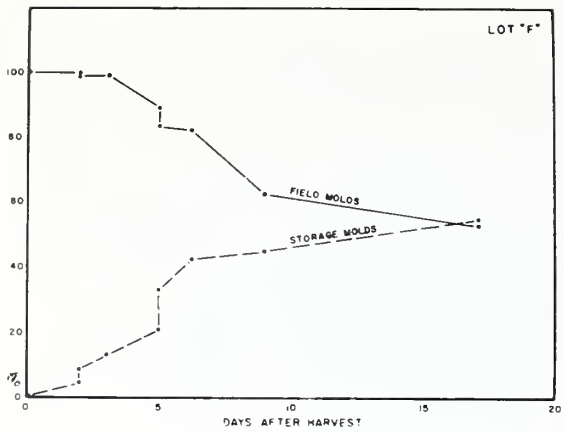

Figure 1.--The prevalence and composition of the mycoflora of rough rice as affected by multipass heated air drying with aeration between drying passes.

as limited to yield of head rice. Growth of fungi in the kernel weaken the kernel structure and may result in kernel breakage during milling. Table 1 illustrates the ability of two fungi to cause a reduction in head yield (2). In this experiment, head rice

Table 1.--A comparison of the effect of two fungi on the yield of head rice from Nato rouch rice previously sterilized then inoculated and incubated for 7 days

Fungus culture No.	Head rice yield Pct.	Reduction in head rice yield Pct. of control
R-1	28.5	43.6
R-3	17.1	66.1
None (control)	50.5	

yield was reduced 43 percent by culture R-1 and 66 percent by culture R-3. Our studies indicate that the kernel structure is weakened by penetration of the fungal hyphae into the endosperm where it metabolizes the binding material between the cells (1). A cross section of the endosperm of a rice kernel infected by Helminthosporium oryzae shows this pattern of hyphal development (fig. 2).

The affect of fungal activity on cooking quality is not well understood. Low levels of activity may indeed improve cooking quality as suggested by the well known phenomenon of cooking quality improvement associated with aging. It is not beyond the realm of possibility that the fungi may play a part in normal aging. However, we have

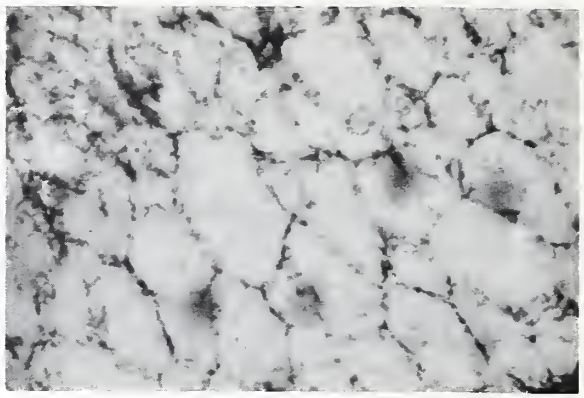

Figure 2.--A cross section of a rice kernel infected by Helminthosporium oryzae.

demonstrated that the cooking score as determined in the laboratory tends to be poorer when increased fungal activity is induced in stored rice (6).

Under the heading of consumer acceptance, I am discussing only kernel discoloration; that is damage, heat damage, and overall color of milled rice. Our studies have indicated that most damaged kernels result from the activities of field fungi. As an example, observe thd discoloration experimentally induced in rice by inoculation with Curvularia lunata (fig. 3). Other field fungi

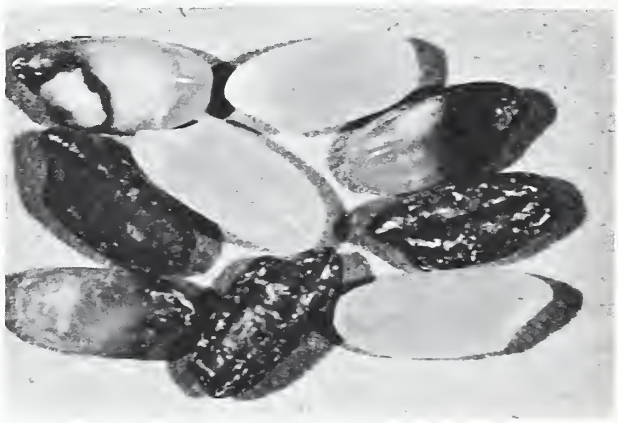

Figure 3.--Kernel discoloration in rice after inoculation with Curvularia lunata.

produce similar discolorations. The most prevalent damage of this type is caused by Helminthosporium oryzae (1). Various Fusarium spp. often cause a red discoloration in a similar fashion. Our experiments indicate that most of the discoloration caused by field fungi occurs prior to harvest but it may be increased in high moisture rice held for several days before drying is begun.

Some storage molds also can discolor individual kernels as illustrated by the orange stain (fig. 4) caused by Penicillium puberulum (3). Marked discoloration of individual

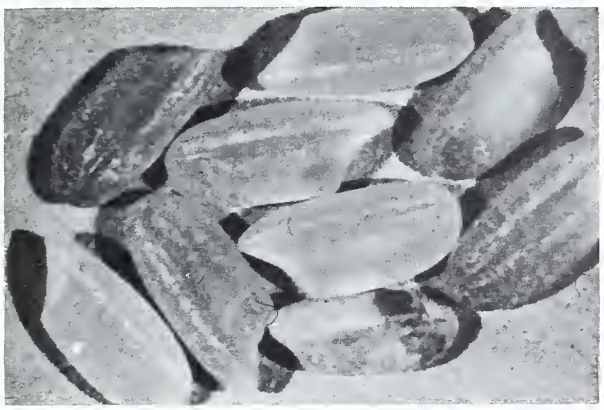

Figure 4.--"Orange stain" of rice caused by Penicillium puberulum.

kernels indicates a high level of fungus activity in a particular kernel. Since the metabolic activity of storage fungi is usually low under the average post-harvest environmental conditions, the more common visual results are a gradual change in the general color of the endosperm from white to creamy, rosy, gray, or even light yellow. We have experimentally demonstrated this overall color change and its association with fungal activity.

The cause of the more serious type of kernel discoloration called "heat damage" has not been clearly demonstrated. We have from time to time induced heat-damage symptoms in as high as 5 percent of the kernels of a sample of rice inoculated with particular cultures of species of the Aspergillus flavus group. However, repeating the experiment with the same isolate often fails to induce heat damage. Our failure to experimentally achieve uniform, consistent heat-damage symptoms suggest that such symptoms result from an interaction between the fungus and substances in rice that are not uniformly present in all rice kernels.

Under the quality category that I am calling nutritive value, there are many factors related to fungal activity. Fungus metabolism causes a loss in dry weight (table 2) primarily from the break down of carbohydrates and other constituents as a source of energy, releasing water and carbon dioxide. Changes in kernel constituents

Table 2. --The effect of growth of two fungi on the dry weight of rice after 7 days incubation following sterilization with subsequent inoculation

Fungus culture No.	Dry weight after 7 days g.	Loss in dry weight Pct. of control
R-1	126.7	3.3
R-3	130.0	.8
None (control)	131.0	---

are also brought about by fungal metabolism (5). We have demonstrated that the concentration of free amino acids may be increased in rice and the number of amino acids may also be increased (table 3). Many fungi develop a high level of amylase activity and may significantly increase the concentration

Table 3. --Free amino acids in Bluebonnet rice as affected by H. oryzae infection and parboiling

Reaction with ninhydrin: tr. --Trace +--Weak ++--Moderate +++--Strong

Item	Noninfected		Infected	
	Non-parboiled	Parboiled	Non-parboiled	Parboiled
Aspartic acid	tr.	+	tr.	++
Glutamic acid	tr.	+	+++	+
Serine	+	+	++	++
Glycine	+	+	++	++
Threonine	+	tr.	++	++
Alanine	+++	++	+++	+++
Valine	tr.	tr.	+	+++
Isoleucine	tr.	tr.	+	+++
Leucine	tr.	tr.	+	+++
Phenylalanine			tr.	+
Tyrosine			tr.	tr.
Tryptophan			+	+++
Histidine			++	+
Lysine			tr.	++
Arginine			++	++
Proline	tr.		++	+
Methionine	tr.	tr.	+	+++
γ-Amino-n-butyric acid	tr.	tr.	++	++
Asparagine		tr.	++	
Glutamine			+++	tr.

of reducing sugars in the kernels. Of equal or perhaps greater importance, metabolites

of the fungi may be excreted from the mycelium in large quantities and may be adsorbed in the endosperm or stored in the fungal cells.

The importance of such metabolites has been emphasized in recent years by the discovery that some metabolites of one of the most prevalent groups of storage fungi in rice and many other crops, the Aspergillus flavus group, are highly toxic to many warm-blooded animals. These toxic metabolites are collectively called aflatoxins. Extensive research programs have been initiated on this problem in the United States and many foreign countries.

Our program includes a laboratory study of factors affecting the production of aflatoxins in rice. Our preliminary results with the 1965 rice crop indicated that aflatoxins can be produced in significant concentrations in high moisture rough rice after storage for as little as 2 days. Laboratory experiments also indicate that 25° to 35 °C. is optimum for both growth of the fungus and accumulation of aflatoxins.

It should not be inferred from these statements that all fungal metabolites are harmful. On the contrary, they may in fact be beneficial in some cases. Dr. Richardson of Texas A&M University has reported increased growth in laboratory animals fed moldy grain over animals fed the same grain in a relatively mold-free condition 1/. He has been able to show that the favorable growth response was due to an increase in essential amino acids that resulted from fungal metabolic activity.

The many genera and species of fungi that make up the mycoflora of rice coupled with the dynamic aspects of this ever-changing population emphasize the complexity of this problem in quality control of rice. Fortunately, man discovered early in history that the activity of the fungi can be largely controlled by drying his crops to a low moisture level before storage. This method is still the most satisfactory and economical method of control that man has yet devised. However, there is still room for improvement in drying and handling techniques. Continued research in this area is needed to improve and maintain the present efficiency of the rice industry and to meet the challenge of technological changes in production and processing. The fungi, like the poor, will always be with us. Their numbers and genetic variability are so great that I for one do not anticipate that associated problems will all be completely solved in the forseeable future.

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DISCUSSION

Question: Is pseudomonos observed in this country? It usually protects the grain from secondary infection.

H. W. Schroeder: That is usually not a factor.

Question: Did you use gamma irradiation to kill micro-organisms?

H. W. Schroeder: Yes, rice has been irradiated experimentally in the United States, but since I don't actually work in that field I have no specific comments.

1/ Richardson, L. R. 1965. Presented at Annual Experiment Station Staff Conference. October.

Question: Can you improve quality by adding harmless fungi?

H. W. Schroeder: This has not been determined. In our study, it was not an improvement in rice quality, simply an increase in free amino acid content.

Question: Do you find aflatoxin in normal rice?

H. W. Schroeder: It is a minimum problem with rice.

Question: What is the moisture content of the colored rice?

H. W. Schroeder: I don't actually know. They were specially prepared using a presterilization step in order to grow only one fungus.

Question: Does the weight loss due to microbe growth cause a loss in the rice?

H. W. Schroeder: Yes, any loss is important.

Question: What are the limits on moisture content in order to inhibit the growth of these micro-organisms?

H. W. Schroeder: It varies with the species. In general, about 12 percent or less will inhibit almost all of these fungi. There is no maximum limit. Some of them will grow in a saturated aqueous medium.

WASTE DISPOSAL IN PROCESSING RICE

by
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The problem of waste disposal of materials resulting from the processing of rice has, in years past, centered largely on rice hulls. The problem remains with us to this day. In the past 25 years, numerous operations, auxiliary to the milling of rice have emerged. These new developments are important to the growing rice industry. The years ahead will most certainly see additional changes in processing methods and processed products. At the same time the increasingly large volumes of wastes these new operations yield, require that discharge wastes of one kind or another must be properly handled so that they do not cause pollution. Every available means must be used to convert them into products which have some utility and value to contribute to the economics of the base operation. Most rice milling operations are located in growth areas, where, with its associated increase in volume of waste, places an increasing burden on the surrounding area and facilities capacity to assimilate the waste.

Waste is defined as something not put to use, anything unused, unproductive, or not properly utilized; anything left over or superfluous--not of use for the work in hand; or to consume, spend, or employ uselessly or without adequate return. Thus, if this definition is acceptable, wide latitude in this presentation will be tolerated.

The conventional waste material from the processing of rice pollutes our environment as solid waste material; liquid discharges to streams, lakes, resevoirs, underground streams, and water supplies; dusts, and condensed fumes.

Dusts may be characterized as minute solid particles released into the atmosphere by natural forces, or by mechanical processes such as crushing, grinding, milling, drilling, demolishing, shoveling, conveying, covering, bagging, sweeping, and so forth; condensed fumes may be characterized as minute solid particles, generated by the condensation of vapors from solid matter after volitalization from the matter state, or may be generated by sublimation, distillation, calcination, or chemical reaction, when these processes create air-borne particles.

The Solid Waste Disposal Section of the Clean Air Act Amendments and Solid Waste Disposal Act of 1965 (P. L. 89-272) like other legislation in the area of environmental pollution control, recognizes that the primary responsibility for dealing with these problems rests with State, regional, and local agencies. However, these levels of government look for guidance and aid to the Federal Government. The Solid Waste Disposal Act is

intended to enable the Federal Government to help create a coordinated National Solid Waste disposal program by bolstering the efforts of State and local governments. The high rates of production and consumption made possible by advancing and changing technology, coupled with a sharply rising urban population have created a waste disposal problem that outstrips the handling resources and facilities of most communities. The inability of communities to handle these wastes significantly contributes to community air pollution, pollution of streams and lakes, to rodent and insect problems, to safety hazards, and to urban and exurban blight. Unless prompt steps are taken to correct and minimize the accumulation and handling of these wastes, there can only be a worsening of these problems. It is not a function here to pass on the alleged esthetics of this situation or raise unesthetic thoughts in the minds of the audience. It is felt, however, that the rice industry must "tool-up" and compile necessary information required for proper waste disposal and urge all governmental agencies to develop standards that are practical and meaningful from the standpoint of the industry and yet are in the best interests of the community. There are engineering challenges involved in developing new methods of handling and disposing of these wastes with costs which do not discourage the development of new processes.

Any highly populated and vigorous urban complex faces the same fundamental problem of best utilizing an essentially fixed water resource in the face of ever increasing demands for water. Waste waters provide a source of water where they can economically be retained for use. Water pollution control is a real and major cost-of-doing business to industries in California. Adequate control depends on:

1. Equitable and understanding regulation.
2. Well informed management.
3. Clear identification of responsibility.

In California, the State and Regional Water Quality Control Boards are the State agencies responsible for the control of water quality and for the prevention, control, and abasement of water pollution and nuisance resulting from discharges of sewage and industrial wastes. These responsibilities of the Water Quality Control Boards apply equally to all of the various topographical areas within the State and provide for coordinated control of water quality. According to the pollution Laws, all that has to be done is find a waste discharger, establish requirements for the discharge, discover a violation of these requirements, and then lower the boom.

Section 13063 of the Water Pollution Control Act provides that when any discharger fails to comply with a cease and desist order of the Board, the Board shall certify the facts to the District Attorney for the county in which the discharge originates, whereupon the District Attorney shall petition the Superior court in and for that county for the issuance of an injunction restraining the discharger from continuing the discharge in violation of the requirements. Fortunately the Regional Boards have not adopted an arbitrary means of protecting the waters of the State.

There has now been established a Federal Waters Pollution Control Administration under the provisions of the Water Quality Act of 1965. This new agency will administer a national program to prevent, control, and abate water pollution and to enhance the quality and value of the Nation's water resources. Recent directives by the California State Water Pollution Control Board will require sewage treatment facilities which dump into the Sacramento River to provide for secondary treatment thereby reducing by 80 percent the biochemical oxygen (B. O. D.) demand in line with current requirements now in force on all dischargers to a particular reach of the Sacramento River. Recently the rice industry in California was involved in an arrangement whereby the location of a large scale processing plant near the milling center to utilize the total output of rice hulls was given serious consideration. It would have relieved the industry and the immediate area of an increasingly troublesome waste disposal problem. The original plant investment estimate was expected to run into several millions of dollars. In the overall plan it was proposed that the Sacramento River be utilized as the receiving waters for the discharge of the biodegradeable containing wastes. The discharges were to be continuous during plant operation with an expected 24 hour per day operation on a 7 day per week basis. Except for maintenance shut down, no seasonal variation in discharge was anticipated. A high biodegradeable waste amounting to approximately 120,000 pounds per hour (240 gallons per minute) was possible and the maximum. Water from the

river was to be used for a process cooling amounting to approximately 2,500 gallons per minute with returns to river of the heated water carrying a heat load of approximately 85 million B.t.u.'s per hour. The proposed discharges were to be almost waterwhite, having no turbidity and a minimum of odor, and require a 5 day B.O.D. of about 310 pounds of oxygen per hour. The waste discharges would have substantially no solids, either suspended or dissolved, a pH of about 2.5, and a total absence of grease and oils. A request was made to the State of California, Resources Agency, Regional Water Pollution Control Board, Central Valley Region, for an assessment of the opinions of the several agencies and some guidelines for the preliminary planning on the disposal of the projected wastes. The guidelines established were as follows:

1. Disposal of cooling water should not increase receiving water temperature by more than 0.5°F. This probably necessitates some sort of disposal system to prevent localized hot areas.

2. pH of any discharge should be maintained within the range 6.5 to 8.5.

3. The B.O.D. load of 7,440 pounds per day is acceptable into the river on a temporary basis. By April 18, 1968, this loading should be reduced by 80 percent, in line with the current requirements now in force on all discharges to this reach of the Sacramento River. Delivery of these wastes into the West Sacramento Municipal System, as projected, would meet this objective.

4. Neutral salts contained in the proposed discharge do not appear to be of concern at this time.

5. Discharges must not cause objectionable odors or unsightliness, such as discoloration or foam.

6. Discharges must not cause concentrations of substances in receiving waters which are deleterious to human, plant, animal, or aquatic life.

7. Water treatment chemicals, such as may be applied to cooling waters, boiler waters, or water softening, should be carefully selected to avoid toxic effects in the receiving waters.

8. Domestic wastes must be treated in such a fashion as to prevent pollution or contamination of the receiving waters.

9. Additional information is requested in an estimate of the total nitrogen and phosphate content of the discharge.

The foregoing represents only part of the problem regarding waste disposal from the projected operation. In the planning, economics of the operation dictated that the solid residue from operations be incinerated and the resulting B.t.u.'s utilized for steam generation, thus reducing the volume of the residue and holding the solid waste disposal problem to a minimum. The matter of air pollution is covered by the "Rules and Regulations of the Air Pollution Control District--County of Sacramento." Most of the rice milling capacity in California is located in the County of Yolo adjacent to the County of Sacramento separated from the city of Sacramento by the Sacramento River. Thus, the rice milling center is not included in the Air Pollution Control District of the County of Sacramento. However, advanced thinking is in terms of air systems or the entire air mass available daily to a community. Its volume is determined by both topography and meterology and is visualized as a slow moving river of air having a depth of from 500 to 1,500 feet passing over a community. The wastes discharged into this air mass come from a very wide range of activities which produce dust, smoke, gas, and vapors. Frank Stead, Chief of the Environmental Sanitation Division of California's Department of Public Health, told the Institute of Sanitation Management Conference: "Our States are rapidly becoming populated to the point where they must be thought of as environmental capsules on a larger scale, in which air, water, and food systems operate on a closed basis. Reliance can no longer be upon the principle of waste disposal by dilution. Successful management of a 'capsule' as large as the State of California requires a centralization of management authority hard to bring about in a culture of home rule and private enterprise autonomy."

Further, with the signing by President Johnson on October 20, 1965 of P.L. 89-272, the Federal Government assumed major new responsibilities for the prevention and control of air pollution. This legislation amends the Clean Air Act of 1963 (P.L. 88-206) by

giving the Secretary of Health, Education, and Welfare, authority, among other things:

1. To investigate and seek to prevent new sources of air pollution from coming into being; and

2. To construct, staff, and equip facilities needed by the Department to carry out its increased responsibilities under the amended Clean Air Act.

The Clean Air Act Amendments and Solid Waste Disposal Act provide important new tools to help forge a comprehensive attack on the growing national problem of community air pollution. Under the Clean Air Act of 1963, the Department of Health, Education, and Welfare, has undertaken the formation of a national program for the prevention and control of air pollution. The amendments to the Clean Air Act and the Solid Waste Disposal Act will enable the Department to carry its efforts further in several of the most critical areas of the complex problem of air pollution. The Act also provides for a steady increase in research and development activities relating to air pollution sources, the development of air quality criteria based on knowledge of pollutional effects, and the need to provide training for persons involved in air pollution control activities at State and local levels.

Incidentally, the plans for the projected plant designed to utilize the total output of rice hulls from the California rice industry are now in abeyance, pending a review of plant investment requirements, inasmuch as the additional costs of waste disposal, due largely to the regulations and restrictions, present and anticipated, almost doubled the capital investment necessary. Here, then, is a clear case of a major move in the direction of relieving a perplexing waste disposal problem, in the form of rice hulls, which was thwarted due to the restrictive nature of the rules and regulations established for the control of refuse disposal.

It must be concluded that the day has long since gone when industry can create a mess and then move away from it to some other hunting ground across the river. We can no longer count on dilution to solve our problems for us. The air is becoming polluted; the streams are polluted, and so are even the greatest lakes, and much of the ocean's shoreline. Pollution control is a must--more pollution control is essential. The waste disposal programs developed by the rice industry can no longer stop at the back door, or at the top of the smoke stack, or at the end of the pipe into the local stream.

DISCUSSION

Question: How do you use rice hulls?

R. Mickus: We plow them into the soil. We have the furfural process under investigation.

THIRD SESSION: K. K. Keneaster [1], Chairman

REVIEW OF USDA RESEARCH ON CEREALS

by
F. R. Senti
Nutrition, Consumer and Industrial Use Research, USDA
Washington, D. C.

This National Rice Utilization Conference has afforded me my first opportunity to appear before an audience interested in rice and rice research--an opportunity which is sincerely appreciated. The rice industry is to be complimented for organizing this conference. It will serve as an instrument whereby the industry's research needs can be identified and evaluated.

Utilization research has had long and extensive contacts with agricultural industries and their associations. In the southern region these contacts have been largely in connection with such commodities as cotton, cottonseed, citrus, and peanuts; and to a lesser extent with sugarcane, rice, and vegetables. In general, it may be said that as the utilization researcher's knowledge of

1/ Uncle Ben's Inc.

commodity problems increase, the greater his contributions are likely to be to their solution. Also, an enhanced understanding of the respective needs and efforts of industry and research is essential for obtaining increased support for work on those commodities for which research needs are apparent.

Attendants at this conference are particularly interested in rice and rice research. As a cereal grain, rice competes for markets with the other grains (it has done very well in this respect in the past several years) and it also competes for research funds. You may be interested, therefore, in a view of our overall research program on cereal grains, some statistics on the relative size of the effort on the various grains, factors contributing to the size of the programs, and some of the problems being attacked by research.

Let's consider first the funds that are being expended for research on the various cereal grains. The Department and the State Agricultural Experiment Stations are now engaged in developing a long-range plan for agricultural research. This plan is to outline research needs of agriculture over the next 10 years. It was initiated in early spring 1965 at the request of the Secretary. Additional impetus was given to the undertaking by the Senate Committee on Appropriations in its Report No. 156 (April 9, 1965) on the FY 1966 appropriation in which it recommended that the Secretary establish a research review committee to examine fully each and every line of agricultural research conducted by the USDA and the State agricultural experiment stations.

The first step in preparing for this long-range planning was to develop a systematic inventory of current lines of research as a basis for analyzing the research program and projecting future needs. This inventory, expressed in lines of work on various agricultural resources (crops, livestock, soil, and water), with funds allocated to each, enables a comparison to be made of the effort expended on the various cereal grains.

Such a comparison is presented in table 1. In this table funds expended on cereal grains in FY 1965 are broken down by the three major areas of research: production, utilization, and marketing research.

Table 1. --Research expenditures by USDA and State Agricultural Experiment Stations in FY 1965 on cereal grains

Cereal grains	Production research	Utilization research	Marketing research
	1,000 dol.	1,000 dol.	1,000 dol.
Corn	6,248	2,954	786
Wheat	4,790	3,526	1,421
Grain sorghum	1,446	246	202
Rice	882	157	279
Other small grains	3,665	114	227

Production research includes research on plant breeding, insect, disease, parasite and weed control, cultural, and engineering practices.

Utilization research is that kind of research conducted at the Southern Regional Research Laboratory and is concerned with research on the chemical and physical properties of farm commodities and the development of new and improved products and processes for manufacturing them.

Marketing research includes research on efficiency in marketing, supply, demand, price, and market development both domestically and abroad.

Each entry is the sum of the expenditures of the Department and the State Stations. In considering research on a commodity, this is the logical figure to examine.

The first thing that may be noted from table 1 is that funds for production research on all grains are considerably more than funds for either utilization or marketing research. Indeed, production research funds exceed the sum of utilization and marketing research. Expenditures for corn in FY 1965 were $6.2 million for production research, $2.9 million for Utilization research, and $786,000 for marketing research for a total of $9.0 million research on corn. For wheat, $4.8 million was spent on production research, $3.5 million on utilization research, and $1.4 million on marketing research. Expenditures for rice were $882,000 for pro-

duction research, $157,000 for utilization, and $279,000 for marketing. For other small grains (oats, barley, and rye) the major expenditure was $3,665,000 for production research.

The range of research expenditure on the grains is wide. It is interesting to compare the total expenditure with the farm value of the crop (table 2). It is evident that

Table 2. --Research expenditures by USDA and State Agricultural Experiment stations in FY 1965 on cereal grains and the proportion of farm values based on research

Cereal grains	Total research	Farm value	Research / Farm value
	1,000 dol.	1,000 dol.	Cents per dollar
Corn	9,988	4,553,300	.22
Wheat	9,737	1,770,100	.55
Grain sorghum	1,824	665,600	.27
Rice	1,318	377,300	.35
Other small grains	4,006	1,050,000	.38

corn with the greatest farm value also has the most research funds allocated to it.

A more quantitative comparison can be made by calculating research expenditures in terms of cents per dollar of farm values. These values are given in the last column of table 2. Only 0.22 cents per dollar farm value is spent for research on corn. Relative research expenditures for wheat are highest, 0.55 cents per dollar farm value being spent in FY 1965.

Expenditures for rice were 0.35 cents per dollar, about the same as spent for grain sorghum and barley, oats, and rye.

Since we are concerned with utilization research today, and particularly with that conducted by the Department, it may interest you to compare our expenditures for utilization research on the cereal grains. This information is given in table 3. Expenditures for wheat and corn greatly exceeded those for the other grains in FY 1965. About $2.7 million was spent for corn whereas only $152,000 was spent for rice. Although widely disparate on an

Table 3. --Utilization research expenditures by USDA on cereal grains in FY 1965 and the proportion of farm values based on research

Cereal grains	Utilization research	Research / Farm value
	1,000 dol.	Cents per dollar
Corn	2,649	.059
Wheat	3,185	.18
Grain sorghum	246	.037
Rice	152	.040
Other small grains	36	.003

absolute basis, these expenditures are closer together when considered on the basis of farm value. The last column gives research expenditures in cents per dollar of farm value. On this basis, wheat is again high, 0.18 cents per dollar being spent. Other small grains are extremely low with only 0.003 cents per dollar farm value being spent. Rice expenditures were somewhat less than corn, and about the same as grain sorghum. Several considerations may be advanced in support of the amount spent for research on a commodity. I have already mentioned farm value. Related to this is acreage given to the production of the crop and the geographical distribution of the producers as indicated by the number of producing States. Table 4 presents this information in columns 2 and 4, respectively. This

Table 4. --Current acreages for cereal grains as compared with maximum acreage harvested in past 1/

Cereal grains	1965	Maximum		Producing States
	Million	Million		Number
Corn	57	100	(1930's)	42
Wheat	49.3	75.9	(1949)	43
Grain Sorghum	13.3	19.7	(1957)	23
Rice	1.79	2.55	(1954)	13

1/ The 1966 acreage allotment for rice was increased 10 percent to 2,000,502 acres. This increased acreage authorization was in response to White House Food for Freedom message to Congress. In his message, the President said: "Unprecedented demands arising out of drought and war in Asia require us to increase our rice crop this year."

table (column 3) also shows the maximum acreage for each of the cereal grains and the

year in which the acreage was harvested. Both wheat and corn have had large reductions in acreage as a result of increasing productivity per acre without corresponding increases in markets. Although corn has suffered the greatest reduction, the contraction has come over a much longer period of years, beginning in the 1930's. This was the time that hybrid corn was introduced into the Corn Belt and brought a substantial yield increase.

As shown in table 5, the carryover for corn has never been as great as for wheat when considered as a percentage of the annual crop. The magnitude of the problem, as indicated by the carryover, has brought pressure for research to develop new markets for wheat as well as for corn.

Table 5.--Carryover stocks of cereal grains

Year	Wheat		Corn		Grain sorghum		Rice	
	Million bushels	Percent average production	Million bushels	Percent average production	Million bushels	Percent average production	Million bushels	Percent average production
1950	425	42	845	31	60	26	3.5	9
1955	1,036	111	1,035	36	75	31	21.7	48
1960	1,314	97	1,787	46	581	94	12.1	22
1965 1/	818	62	1,160	28	566	86	7.7	10

1/ Projected.

Articulation of research needs by grower organizations and processor groups are important in focusing attention on a commodity.

With the foregoing discussion of the funding of research on cereal grains, I should like to comment briefly on the Agricultural Research Service utilization research program on cereal grains. My comments will be directed to our work on wheat, corn, and sorghum since Dr. Deobald, Southern Utilization Research and Development Division and Dr. Pence have discussed our program of rice research.

Our research program on wheat is centered on the following problems:

1) Development of maturing treatments for hard red winter wheats which do not involve chemical agents banned by European countries.

   Determination of carrying capacity of United States hard wheats for European weak wheats.

2) Development of new food products from wheat for foreign and domestic markets (Bulgur, peeled wheat, wheat Tempeh, wheat protein from mill by-products).

3) Development of basic information on the relationship of chemical structure of wheat proteins, starch, lipids, and other wheat constituents to functional properties of wheat doughs as a basis for adapting wheats to automated baking processes and to the improvement of quality of bakes products.

   Development of processes for the recovery of wheat gluten from wheat flour. Gluten is used for the fortification of breakfast food and bread.

4) Development of improved milling processes such as air classification, and evaluation of the products for food and industrial uses (Air classification is particularly advantageous for hard wheats which are too low in protein for bread baking but too high for cookie and cake flours.).

   Development of processes for the pasteurization of flour at the mill and at the bakery.

   Removal of radioactive fallout from wheat, flour, and millfeeds.

   Microbiology of wheat flour in relation to its use in frozen food and in unbaked food products.

5) Improvement of the nutritive value of mill feeds which constitute about 25 percent of the wheat milled.

6) Determination of reason for lower feed value of wheat as compared to corn for beef cattle.

7) Development of industrial uses for wheat flour and wheat starch.

With lowered support price wheat is competitive with corn in Pacific Northwest and on West coast.

The utilization research program on corn conducted at the Northern Regional Research Laboratory concentrates on the development of industrial uses.

Corn starch at 5 to 6 cents per pound is competitive in industrial markets. Indeed, about 2 billion pounds of starch now find non-food uses. One of the promising markets for starch is in the expanding paper and paper products industry. U. S. production is now 43 million tons per year, and production is increasing at the rate of 3.3 percent per year compared to Gross National Product growth of 3.4 percent, and a population growth rate of 1.7 percent per year. Research on starch has paid off in this area. Use of starch by the paper industry doubled between 1950 and 1963. Average amount of starch used per ton of paper increased from 19 to 29 pounds. Growth rate of starch consumption by the industry is 5.6 percent per year compared with 3.4 percent for the industry itself.

Important areas of research on corn starch are:

(1) Development of new starch products for the paper industry: for coating adhesives, wet and dry strength agents, wet-wet strength, grease proofness for specialty papers, and opacity.

(2) Development of new polymeric products for adhesives, thickners, and coatings from starches and flours. (Opportunities exist in this area for new starch-petrochemical graft copolymers, microbial polysaccharides, modified starches for use as water-resistant adhesives (plywood and laminating adhesives), foamed plastics, protective colloids for emulsion paints, and protective coatings. The overall growth of adhesive consumption is almost 7 percent per year. This 2 billion pound annual market is dominated by starch which accounts for nearly one-half. However, this outlet is constantly threatened by synthetics).

(3) Biological pesticides and antibiotics for plant disease produced on cereal grain substrates.

(4) Industrial chemicals and pharmaceuticals from corn starch and its derived products; (Products that have come from past research include sodium gluconate, saccharic acids, 2- and 2-ketogluconic acids, Vitamin B_2, Vitamin B_{12}, giberellin, penicillin, fungal amylose, and glucamylose).

(5) Development of new starches through genetic research such as the waxy starches in World War II, and high amylose starches (approaches to new starch products may be through chemistry; through fermentation--vitamins, organic acids, microbial polysaccharide, and through genetics--high amylose corn, waxy corn, high lysine corn).

In closing, I should like to reiterate that it is important to identify the opportunities where research can expand the market for rice through the development of improved processed products and processes. We also need to know areas in which basic research can contribute new information on which practical developments may be based. The Department is grateful to the rice growers, processors, and industry associations, for progress made in its utilization research programs. We hope that friendly, cooperative relations between the Department and the rice industry will continue to grow. This growth is necessary to supply the impetus for increased and more effective utilization programs on rice.

DISCUSSION

Question: To what extent is grain research interchangeable?

F. R. Senti: Corn and sorghum are interchanged industrially. The starches are similar. If the granule is not destroyed, then some minor differences exist, as, for example, in the granule size distribution of wheat and corn starches.

Question: What is in the future for rice starch research?

F. R. Senti: This is a question of cost. Rice is just too expensive for industrial applications. Only the discovery of an unusual property could justify its use.

PRODUCTION OF AND CHARACTERISTICS DESIRED IN RICE FOR RICE KRISPIES AND SPECIAL K

by
Col. J. P. Littlejohn, USA, Retired
Kellogg Company
Battle Creek, Mich.

I bring you greetings from Kellogg's and its best wishes for a productive conference. Any progress made in the culture and milling of rice as a result of conferences such as this, helps Kellogg, for 18 of its plants located in 15 countries around the world last year consumed nearly 200 million pounds of milled rice. Nearly three-fourths of this was purchased in the United States, which makes Kellogg, I believe, the largest single purchaser and processor.

It has been stated that rice was first planted in this country in 1685 along the coastal regions of South Carolina. Its movement west to this great production area came just after the Civil War. I mention this point only to establish myself as an expert, having come from Carolina and having eaten rice twice a day myself during my early years. This reminds me of a local story that the Carolinian, like the Chinese, eats rice through his nose--at least he doesn't miss it very far. Since I have become associated with Kellogg's, however, I have really begun to appreciate this great international food.

Kellogg Company manufactures a number of ready-to-eat cereals using rice as one of the raw ingredients. My mission today is to discuss only two of these--RICE KRISPIES and SPECIAL K--both patented products which are unique to Kellogg, and generally regarded as classics by cereal technologists. In the first instance, rice is oven puffed and stays that way, crisp and delicious. In the second, rice is used as a base for building a 20 percent protein cereal. I propose to review the manufacturing steps, beginning with Rice Krispies, then conclude with some comments on milled rice which are appropriate to good manufacture.

Way back during the depths of the Depression, a man by the name of Charles E. Luke invented an oven puffed rice, now known as Rice Krispies. While his patented product was not what we are familiar with today, it was one of the major improvements in the art of making ready-to-eat breakfast foods and can be considered on a par with the invention of shredded wheat and the invention of corn flakes. This basic patent was purchased by the Kellogg Company and the product further improved at Kellogg's under the patents of Eugene H. McKay, and so forth.

Prior to these inventions, all rice products attempted seemed too fragile for commercial use, either breaking up during manufacture or mushing during the eating with milk.

I will not extol the nutritional or gastronomic virtues or rice. You are all well acquainted with them. Let me just say for the record here that Kellogg takes advantage of what nature provides and in addition fortifies its Rice Krispies with thiamine, niacinamide, and iron phosphate along with a flavoring of sugar, salt, and malt. All this, plus many years of production experience, has turned out the famous Kellogg SNAP, CRACKLE, and POP.

The fundamental steps in the manufacture of Rice Krispies are:

1. Selecting the rice.
2. Cleaning the rice.
3. Cooking with suitable flavoring until kernels have exactly the right degree softness.
4. Partial drying to remove excess moisture and tempering until the

moisture is uniform throughout the kernel and the kernels are dry on the outer surface.

5. Separating the rice into single kernels.
6. Drying the rice to the proper moisture content prior to flattening (bumping).
7. Flattening the individual rice kernels but not sufficiently to reduce them to flakes.
8. Drying flattened rice to predetermined limits, found to give optimum expansion of the kernel.
9. Allowing the rice to stand until the moisture is uniform throughout the kernel.
10. Oven puffing and toasting the kernel.

Selection of the rice to be used in the manufacture of Rice Krispies is very important to getting the proper degree of expansion in each oven puffed kernel. The final product must meet stated package weights to avoid customer disapproval and violation of Federal regulations and, if the manufacturer is to stay in business, it must be sold at a profit. To do this, the raw rice selected should be of uniform variety, size and moisture; be fully milled translucent whole kernels having a fat content less than 0. 5 percent; and, in addition, meet procurement criteria of availability, assessibility, and price.

Rice can be received both in bulk and in bags depending on the capabilities of the receiving location. Prior to use it is screened to remove foreign material and broken rice.

Proper cooking of the rice is very important to the final product; chemically, the indigestible starches must be transformed into digestible starches; physically, the kernel must become uniformly soft and pliable without destruction of its single identity or rupturing the starch grain. Over-cooking will produce a heavier product which will not expand to the optimum degree and therefore results in a heavier package weight. When undercooked, the eating quality is impaired.

Initial moisture content of the rice is also of considerable concern to the cooking operation. If the rice contains moisture outside the limits set for a definite cooking procedure based on time and temperature, the rice will be either undercooked, if the moisture is too low or overcooked and very sticky if the moisture is too high.

The rice is flavored with salt, sugar, and malt during the cooking stage. Since rice is relatively impervious to flavor penetration, this is an important step in the process.

After cooking the rice is partly dried to remove the surface moisture and to temper under carefully controlled conditions. This reduces the stickiness and toughens the kernel so that it is in perfect condition for bumping. The moisture should be uniformly distributed throughout the rice kernels.

Too short a drying period may result in too much residual moisture which causes the rice to set up in a firm coherent mass during the tempering period which, in turn, causes difficulty in separating this mass into individual kernels. Also, any rice bumped at too high a moisture will not retain its desired bumped shape.

Too long a drying period may result in cracks forming around the edge of the kernel during the bumping process followed by broken kernels and underpuffing of the kernels themselves.

Following the surface drying, the rice must be separated into individual grains and finished drying before going into the bumping mills. This is accomplished by means of rice pickers, grinders, and reels, followed by the final driers.

The flattening process, or bumping, passes the rice through a pair of rotating rolls, so set, that the kernels are slightly flattened and stretched at the same time. The outer portion will maintain a distinct cell pattern while the central portion will be indistinct or devoid of cell pattern.

Following the bumping, the rice is further dried to final moisture level for oven puffing and toasting.

The finishing steps for making Rice Krispies are the puffing and toasting, the cooling, and the packaging. Puffing takes place when the rice first enters the oven. As the heating continues, the color of the product changes both as a chemical transformation of the rice as well as of the sugars introduced into the rice. The walls of the cells and the surface of the kernel are hardened or stiffened in their expanded condition and on cooling become brittle. This characteristic, which provides excellent

staying quality in milk without becoming soggy, is the secret of Kellogg's "SNAP, CRACKLE, and POP."

Special K was developed in the early 1950's to meet a pressing need for a simple highly acceptable breakfast food which provided more protein and vitamins than a single grain could give. There had been a growing awareness of the aging of our population, the increasing number of people over 45 years of age who were either eating too little or eating too much. At the same time, it was noted that the general public was not sitting down to a well balanced leisurely breakfast as they theoretically had in the past and which was proven to be medically desirable. After a great deal of thought and research by J. J. Thompson, and others, Kellogg brought out the bland, good tasting cereal Special K which uses rice as its base, is enriched with high protein flour ingredients and fortified with vitamins, minerals, and amino acids.

The enrichment flour consists of vital wheat gluten, defatted wheat germ, nonfat dry milk, and primary dried yeast. Most important to the enrichment, of course, is the vital gluten which had to be developed for this purpose.

The vitamin-amino acid-mineral fortification includes lysine, thiamine, niacinamide, riboflavin, ascorbic acid, B_{12}, and iron. It is of interest to note that the lysine was first produced commercially and economically in this country by Merck and Company especially for Special K.

The steps taken to manufacture Kellogg's Special K are similar to those used for Rice Krispies with some specific exceptions:

1. Selecting the rice.
2. Cleaning the rice.
3. Cooking with suitable flavoring until the kernels have exactly the right degree of softness.
4. Partial drying to remove excess moisture and tempering until the moisture is uniform throughout the kernel and the kernels are dry on the outer surface.
5. Separating the rice into separate kernels.
6. Drying the rice to the proper moisture content prior to flattening.
7. Surface wetting and coating the kernel with an enrichment flour.
8. Flattening, or bumping, the individual rice kernels more than for Rice Krispies but not sufficiently to reduce them to rice flakes.
9. Drying the flattened rice to predetermined limits, found to give optimum expansion of the kernel.
10. Oven puffing and toasting the kernel.

The exceptions are the application of the enriched flour coating, the bumping and the elimination of the final tempering.

Cooked and flavored rice kernels to be enriched are moistened slightly on the surface just enough to make the kernel tacky and then passed through a blend of the enriching flour. Following this, the kernels are bumped harder than for Rice Krispies but not enough to make flakes. The resultant rice ideally resembles a small cup or rosette. Since the product moisture at this point is lower than for Rice Krispies, tempering can be eliminated or shortened and the kernels passed to the oven puffing and toasting stage.

Now for the final part of my assignment--the characteristics desired in rice for processed food.

Kellogg did its original research and food development for Rice Krispies and Special K using U. S. No. 1 Extra Fancy Blue Rose variety rice as described in the U. S. Standards for Milled Rice, effective August 1, 1939.

We believe now, as we did then, that the best rice for Rice Krispies and Special K should be:

a. Plump kernels of the medium grain varieties. This characteristic generally insures uniform cooking, uniform bumping, and uniform finished product density and package weight.

b. Translucent kernels for uniform cooking, cohesiveness, and application of flavor. Chalky rice produces stickiness due to a penetration of the soft starch by the flavor and other moisture with resultant kernel cracking and breaking.

c. Aged new crop rice before milling. Fresh rice not properly tempered is susceptible to checking and has different production characteristics from

the aged. It is costly for the food processor to juggle his process or hold the fresh rice in separate bins while it ages. I agree with the Southern Laboratory that there is a need for knowledge of the aging mechanism. 1/

1/ Hogan, The Rice Journal, Annual Issue, 1963.

d. Whole kernels with no checks or breaks.

e. Fully milled with a fat content not exceeding 0.5 percent to prevent rancidity in the finished food and insure its keeping quality until consumed without the addition of antioxidants.

PUFFED RICE PRODUCTS

by
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Like many inventions, puffed rice was the result of an accident. In 1901 Alexander Pierce Anderson, working in the research laboratories of the New York Botanical Gardens, theorized that starch granules contained free water. If he could suddenly convert this water into steam he would produce cooked starch. Heating corn starch in hermetically sealed test tubes to 500°F., he broke the tubes. Then he discovered that the corn starch had expanded tenfold into a fluffy, white mass. In quick succession, he followed this up with experiments on cereal grains, including rice. Realizing the commercial potential of his discoveries, he patented his process. Officials of the newly formed Quaker Oats Company became interested. He worked out his process in the company's plants at Cedar Rapids, Iowa and Akron, Ohio. Puffed Rice was introduced to the public in 1904 at the St. Louis World's Fair. This was followed by puffed wheat in 1908, when the phrase "food shot from guns" was first used.

Rice puffing is a relatively simple process, consisting of essentially three steps: (1) Heating the cleaned pearled grain, (2) cooking with steam at high pressures in a sealed chamber or gun, and (3) suddenly releasing the pressure.

Rice Specifications

Before discussing the process let's briefly review some typical specifications of the rice used.

Raw rice. --Of particular importance is freedom from any kind of coating, cleanliness, chalky kernels, and broken rice.

Parboiled rice. --The major specifications are moisture, ungelatinized kernels, damaged kernels, noncontrasting types of rice, and storage time. We do not specify antioxidant treatment, preferring to rely on minimum storage time between milling and processing. Parboiled rice is very susceptible to "rancidity" development during storage. Moisture is an important factor. If above 14 percent in storage, spoilage will occur, due to mold growth.

The Puffing Process

Originally a single chamber was used. The cleaned grain was introduced into the gun manually by a swinging spout, the gun was then closed. With the gun rotating, the heating phase of the process was started. After a period of heat treatment and cooking, steam was then introduced. Sufficient time was allowed to cook the grain to a semiplastic state. The pressure was suddenly released by manually triggering the end gate and the puffed grain caught in a cage, then dried. Numerous patents have been issued to automate the process. Instead of a single gun, we use a rotary machine consisting of eight guns mounted in the form of a wheel, loaded and fired automatically. Clean, milled rice is preheated. This is an important difference to the old single gun process because it allows more precise control of the preheat-step.

It is generally believed that the phenomenon of puffing results from the sudden expansion of water vapor in the starch granules of the grain when the pressure is released. The temperature of the vapor as steam, dextrinizes the starch fixing the

structure after the grain has expanded. Volume of the grain is increased up to 16 times its original volume. Texture, crispness, flavor, and bulk density are functions of time, temperature, and pressure in the three essential steps of the process.

After preheating, steam is introduced into the gun and the grain is cooked to the proper degree of plasticity. It is important that the steam be dry. Free water will cause clumping, pitting, and lower uneven expansion. During the steaming time it is important to develop a pleasing sheen and color to the surface of the grain, with a minimum of pitting and roughness. Steam pressure is critical. If too high, the grain will shatter, when the gun is fired. If too low, the texture of the puffed kernels will be tough, lacking crispness. Proper balance of time, temperature, and pressure is essential for optimum flavor and color development.

Puffing Qualities

Puffing qualities of parboiled rice compared to raw rice are quite different, due to starch modification in the parboiling process. Puffed parboiled rice is darker in color, has a rough surface texture, with coarser internal cell structure, which imparts a difference in eating quality. In spite of less appealing appearance, some people prefer it for the crisper texture and more robust flavor. Because of the precooking modification in parboiled rice, it requires less treatment in the puffing guns. Slightly lower steam pressure and temperature are required. The steaming cycle is longer. At optimum quality according to our standards, the kernels are smaller. There is about a 20-percent decrease in bulk compared to puffed raw rice.

The long and medium grain rice varieties such as Belle Patna and Nato have not been found suitable for puffing, chiefly due to the shape and appearance of the puffed kernels. Consumers are familiar with the characteristic shape of the puffed California short grain rice and would regard the long-grain product as nontypical. Long grain varieties tend to expand in a nonuniform manner giving many of the kernels an odd shape.

We have also found that extruded cereal products made with flour from southern varieties do not expand as well as the California types. Texture tends to be gummy and dense. We have no explanation for the differences. It is my opinion that these variations in physical properties under the different processing conditions are due mainly to variations in the amylose per amylopectin ratios in the different varieties. There appears to be an optimum ratio necessary for desirable puffing and expansion properties. Furthermore, the optimum ratio for a given variety may vary from crop to crop. Environmental as well as genetic factors are involved.

Protein content does not appear to be as much of a factor as the starch. This is not true of wheat. Optimum puffing quality is obtained with the use of durum wheat, which contains a very tough gluten. Incidentally, it is the toughness of durum gluten that makes it eminently suitable for macaroni products.

One of the troublesome features of puffed rice from the consumer acceptance standpoint is that the small portion of germ remaining on the milled rice, turns black in the puffing process. Apparently consumers are not concerned if the small speck remains on the kernel. But some of them are rubbed off in the package and the last serving or two may contain an excessive amount of these black flakes and people think they are dead insects. This problem is particularly troublesome in individual serving packets.

From a quality standpoint, maintenance of crispness of puffed rice is critical. When moisture reaches around 6 percent, it loses its delectable crispness, becomes tough and softens too quickly when served with milk. The delicate cooked rice flavor, however, is not affected. It is, therefore, necessary to use a good moisture barrier for package liners.

Research Needs

Research is needed on the determination of optimum amylose per amylopectin ratios as they affect puffing and expansion properties. Effects on cooking quality are fairly well documented.

For our purposes we would like to see fewer varieties on the market since contrasting classes in commercial rice give problems in maintaining uniform finished product quality.

Research is also needed into the causes of "rancidity" development in raw rice flour and stored, parboiled rice. I use the word

"rancidity." This may be a misnomer since the problem is not entirely one of free fatty acids by lipolysis. Some of the objectionable flavors that occur are suggestive of fat oxidation and are not necessarily enzymatic in nature, since they develop in parboiled rice where presumably, the enzymes have been inactivated by heat. Although puffed rice contains less than 1 percent fat, it has never gone rancid so far as we know.

DISCUSSION

Question: Could you introduce additives that would increase the ability of the rice to puff?

S. F. Brockington: This has not been investigated. Salt, however, has been tried.

Question: You said that the amylose/amylopectin ratio was an important factor in the puffing process. Have you tried to puff glutinous rice?

S. F. Brockington: No.

Question: Where are some of your rice-puffing plants located?

S. F. Brockington: Cedar Rapids, Iowa and Shiremanstown, Pa.

CANNED RICE PRODUCTS

by
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Campbell Soup Company
Camden, N. J.

As a manufacturer of convenience food items, the Campbell Soup Company is interested in all types of prepared foods containing rice. We all know of many tasty dishes that are made with rice as a main ingredient. If these products are to be made and preserved by canning, we can be quite certain that the cooking characteristics of the rice will be an important factor.

Rice in Canned Soups

If we were to select the products in which rice stability is most important to overall product quality, canned condensed soups would certainly be one of those selected. The rice process (2) includes, first of all, a precooking or blanching treatment of the rice in boiling water for 15 to 18 minutes. The rice, almost completely cooked after the blanching treatment, is blended with the other ingredients and the soup is canned and heat processed. During heat processing the cans may be heated to 250°F. and held for 30 minutes or longer. During both heat treatments, it is important to remember that there is an excess of water present. The water uptake and expansion of the rice kernels is not restricted by the lack of water. Figure 1 shows what happens to the rice kernels in the blanching and heat processing treatment that has been described. The rice kernels in Sample C have nearly lost their identity. The ends of the kernels are split, the surfaces are ragged, and a sloughing of fragments increases the turbidity of the surrounding liquid. Rice that reacts in this way is unsatisfactory for use in Campbell Soup Company products. The rice in Sample B shows some improvement, but there is still evidence of kernel instability toward the heat treatments involved. Sample A shows the type of canning stability that we like to have in rice for heat processed condensed soups. The grains have swelled to a larger

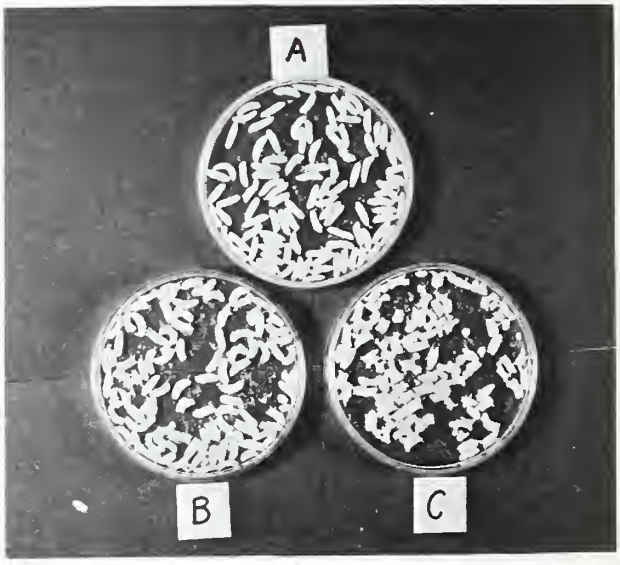

Figure 1.--Evaluation tests of rice samples for use in soup. Effects of blanching and heat processing of rice showing: A, with desirable degree of firmness; B, evidence of kernel instability; and C, unsuitable for use in soup.

size while maintaining kernel identity. The surfaces of the kernel are smooth and noncohesive during the processing treatment. For the best quality rating, we will assume that the rice also has the desirable degree of firmness.

We have illustrated the effects of the canning treatment on three samples of rice. The samples were prepared in the laboratory, but they illustrate a problem of ingredient quality. We should note that rice is not unique in this regard. In most agricultural ingredients used in our products, variations in canning quality and flavor must be reduced by grading and selection in order to meet the quality and uniformity standards of Campbell Soup Company products. Potatoes, beans, peas, tomatoes, okra. and mushrooms are some of the ingredients that come in for the same type of attention given to rice.

Factors that Influence Canning Stability: What We Know and Need to Know

We have shown that there are very significant variations in the canning stability of rice. Let us consider now some of the factors that seem to be involved in canning stability.

Rice varieties. --Long grain rice varieties show great variation in canning stability. During the past 15 years, the long-grain rice varieties having the best canning stability have been Nira, Rexoro, and Texas Patna. Some of the other varieties have shown good stability in certain lots, but lacked consistently good performance. Other varieties, such as, Century Patna, were completely lacking in canning stability. Belle Patna, the variety that has come into prominence in recent years, has somewhat less canning stability than Nira, Rexoro, and Texas Patna varieties.

From this change in the rice varieties grown, we would conclude that canning stability has been a factor in varietal selections, but not a dominant one. However, we must concede that the rice breeders and growers have been eminently fair. They have eliminated both the best and the poorest varieties from the standpoint of canning stability.

We know that varietal changes will be a part of the changing agriculture of the future. Increasing agricultural production will have to be our aim as we accept an ever more important role in trying to meet the world's need for food. It is hoped that the quality evaluation for new varieties will be continued and become even more effective as the understanding of the fundamental factors involved in quality is increased (1). Campbell Soup Company has appreciated the opportunity to have some part in this program.

Chemical composition of rice. --There is considerable information available concerning the chemical composition of rice as influenced by variety and environment (3, 5). A significant difference has been shown in the amylose content of the starch from different varieties of rice (9). We have observed that rice with low amylose content will always have poor stability. On the other hand, it also has been noted that some rice with high amylose content does not have the required stability. This suggests the importance of learning more about the starch fractions. How does the amylose act to stabilize the kernel? Is chain length a factor? What is the role of amylopectin, and in this role are molecular weight, degree of branching, and length of chain factors in stability? Work that is being reported will help to answer some of these questions (6, 8).

The other constituents of the rice kernel certainly must influence canning stability. Continuing with our question approach, what is the role of the protein in the rice kernel? What happens to the protein during heat processing? Does this influence the stability? We have often wondered if amylases could be a factor in canning stability? In starch chemistry, the effects of free fatty acids in restricting granule expansion and in preventing retrogradation of the expanded starch are well known. Do free fatty acids in rice influence starch behavior and ultimately the cooking and canning characteristics of the rice kernel?

Physical structure of the rice kernel. --We have discussed and looked at photographs of rice showing different degrees of canning stability. The performance of rice in canning represents the reaction of a whole rice grain. This has always suggested to us the importance of understanding more about the behavior of the constituents of the rice kernel as the whole kernel is subjected to various treatments. In the whole kernel the interactions of the starch, protein, lipid, and structural parts must be a factor in the behavior of the rice. Important information is being developed in this area that will help provide the background for understanding the

reactions involved in cooking and canning (4, 7).

Special treatments of rice. --Parboiling of rice is effective in developing canning stability. The stability developed depends to some extent on the severity of the parboiling treatment. The clarification of the fundamental nature of this reaction should prove to be helpful. Some varieties of rice do not develop the canning stability desired; other varieties such as Jojutla become extremely firm. An understanding of the fundamental reactions might help us to obtain the desired stabilizing treatment for a broad spectrum of rices.

Summary

In rice for canning a high degree of stability toward cooking and heat processing is required. The rice is parboiled to develop the necessary stability. There are varieties and lots within varieties that fail to achieve good canning quality. Varieties that were satisfactory are being replaced, so there is a definite interest on the part of Campbell Soup Company in broadening the base of supply of suitable types of rice for our products.

Some very useful concepts and relationships concerning rice composition and processing properties have been reported in recent years by many competent workers in the field. It is our feeling that further advances in processing technology and increased utilization of rice will come through even greater understanding of the chemical and physical properties of the rice kernel as factors in the desired performance of the rice.

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DESIRABLE RICE CHARACTERISTICS FOR RALSTON PURINA COMPANY

by
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Ralston Purina Company
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(Presented by F. E. Spring)

I would like to spend a few minutes to acquaint you with some of the reasons why certain rice characteristics are so important to Ralston Purina. I know sometimes our rice suppliers think we are just trying to be hard to get along with, but we have some unusual problems, that you may not be aware of.

California U. S. No. 1 Second Head Milled Rice is normally used by Ralston Purina. Certain types of rice are higher quality than others due to low weed seed and adobe ball count. We are very cognizant of any foreign material present; I will explain the specific reasons for this later.

Also, I might point out that I am covering only those items that are particularly troublesome to us and, consequently, to our suppliers. I have deleted all the other standards normally specified.

Cooking

We use a standard steam cooker for cooking rice. We desire a rice that cooks out evenly, and without undue stickiness. Characteristics that are important here are:

1. A good quality, clean, broken rice.
2. Minimum of chalky grains.
3. Uniform size to assure a good, even cookout.
4. Low attrition factor to keep down flour formation and stickiness.

Cooked Grit Handling

The major characteristic of importance here is the ability of the particular rice used to form a hard glazed surface. This allows the grits to flow evenly through the process, similar to large sand, and reduces hang-ups and choking problems.

Consistent and predictable weep characteristics are important from this handling standpoint.

Shredding

General information. --We use a variation of the standard shredding principle to form the lattice ribbon that makes up our Chex product. This lattice work ribbon is produced when the individual rice particles are welded together by pressure between the rolls. Using this principle, we never reach a totally homogenized condition. Any foreign material in our rice is not mixed in and obscured as happens when rice is ground to make a flour--dough type product. It is concentrated and spread out, where it becomes even more obvious even to the untrained eye.

Weed seeds, adobe balls, dark grains, and so forth. --Every weed seed and adobe ball in the rice shows up as an unsightly streak on the lattice ribbon. As further processing takes place, these streaks become more and more noticeable. Most of them toast out to a dark brown to black color.

This is a most troublesome problem for us. We are using the best gravity, --air, --flotation equipment available to try and reduce the number of these contaminants. Unfortunately, no system is 100 percent effective, and therefore, any foreign material is objectionable. If even one weed seed per hour reaches the rolls, it broadcasts its story ever so plainly right down the line. If it is not detected at one of the many quality control check points, it may greet you some morning soon in your breakfast bowl.

Shape and size of rice grits. --The final texture of our product dictates the shape of the shred groove necessary. The angle of the sides, the depth, and the width are all

important. Even more important to you is the relationship between this shred groove size, and the required size and shape of rice needed to produce a good lattice ribbon.

The best shaped rice we have found to date for our process is a thick-grained variety. We can process others, but very few of the midwestern varieties will even weld during the rolling process due mainly to their thin, long-grained characteristics. They tend to lay flat down into the groove, and fail to weld because of this. Other characteristics no doubt contribute to this problem, but this physical problem seems to be most predominate.

Oil content. --A word about this is in order. Analytically the midwestern and California rice varieties are very similar, with the exception of the fat content. The fat content was, percentage-wise, higher in the midwestern varieties we analyzed. The welding process explained a moment ago, and most starch processes in general, are highly sensitive to fat.

Puffing and Toasting

We have not had any particular problems in this area. By adjusting the many processing variables, the product desired can usually be attained.

Summary

In summary, here are the rice characteristics we feel most important to Ralston:

1. A good quality, clean, broken rice.
2. Very minimum in contaminants, such as: weed seeds; adobe balls; dark grains; chalky grains; damaged kernels, and so forth.
3. A uniform-sized grit.
4. Hard flinty kernel or grit with a low attrition factor.
5. Minimum of flour content.

Areas of Interest--Future Research

1. Reduction in weed seed contamination.
2. New equipment for cleaning out the weed seeds and adobe balls.
3. A short, thick-grained rice variety for growing in the middle west would be of interest.

We devote some time and money to rice work each year, but usually direct this toward utilization of present developed varieties. The projects we normally undertake do not really constitute rice research as you would use the term.

I hope these brief comments help you to better understand our problems or should I say "opportunities."

ANHEUSER-BUSCH'S USE OF RICE AS A BREWING ADJUNCT

by
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St. Louis, Mo.

In general, brewers' rice is employed in brewing as a partial replacement for malt. The result is a beer which is somewhat lighter in taste and body. Since rice is rather neutral to taste, contributing no particular flavor of its own to beer, it is generally considered a desirable adjunct.

Anheuser-Busch currently uses in the area of 100,000 tons of brewers' rice a year. Our general technology on rice is not great. We view it strictly as an adjunct, and we have extended our technology on rice only far enough to help in our purchase of that rice which does not cause processing difficulty and which does not alter flavor of our finished product. We prefer to use brewers' rice rather than any other adjunct if the cost penalty does not become too severe.

Corn and corn products have been found acceptable by many brewers. Since it is more economical to use corn grits, most brewers throughout the world (where laws

permit) are using corn as an adjunct material. Information obtained personally from many of these brewers definitely indicates that although brewers' rice is considered to be somewhat more desirable, the cost penalty for using it is too great. Many of these people expressed the opinion that where their product was concerned, the alteration of flavor resulting from using corn was not great enough to justify the added expense of brewers' rice.

As indicated earlier, our technology of brewers' rice to date is scarcely more than that which is necessary for quality control and purchasing specifications.

We can outline, however, certain features which make a brewers' rice desirable for our use. No reference will be made here to those evaluations such as microbiological tests, trash tests, and so forth. These are standard to the food industry and have no unique applications to rice.

Gelatinization temperatures and viscosity of the gelatinized rice. --Here our major concern is to obtain a gelatinized rice slurry which is sufficiently low in viscosity to flow freely and mix readily with the starch-digesting material.

We have observed some varietal differences between rices in this particular aspect. In general the information which we have obtained agrees with that reported by Halick and others[1/] on differences in gelatinization points.

We prefer rice with a relatively low gelatinization point and rice which gives essentially no batch-to-batch variation.

In brewing, rice is ground, slurried with water, and heated to gelatinization. The gelatinized slurry is subjected to digestion by malt enzymes which convert the rice starch to sugars and dextrins.

We desire relatively low and uniform gelatinization temperatures for brewers' rice. We also require a uniform conversion rate of starch to soluble carbohydrates (predominantly reducing sugars), which is brought about by the alpha and beta amylase activity present in our malt preparations.

Oil content. --An oil content of below 0.75 percent is desirable. In recent years this has proven to be a rather difficult purchasing specification. We are not particularly satisfied with rice that has higher oil content, and would prefer to avoid whenever possible such potential problems as rancidity due to rice oil. Since oil content relates directly to bran residual in brewers' rice, we could state as a general thing that the lower the bran content the more desirable the rice will be.

Seed content. --In general, the levels of seed content have been satisfactory. Since many of the seeds which normally contaminate rice contribute definite flavors of their own, we are prone to grade one aspect of rice quality on the basis of seed content and conclude that the lower the seed content the better the rice.

Adsorbed odors. --We generally experience no difficulty with adsorbed odors. I mention it here primarily because it is one thing we evaluate. In the case of parboiled rice, which will be mentioned later, we have on occasion picked up definite off-odors in samples which we have attributed to the type of processing employed for parboiled rice.

Flinty particles. --Since we handle brewers' rice in a standard fashion, it is desirable that flinty particles in the rice be at a minimum. We want uniformity and maximum yield from brewers' rice; high levels of flinty particles do not allow this. These particles grind poorly and influence final yield of soluble material obtained. These particles appear to contain higher levels of moisture than do other particles in a given rice sample.

Parboiled rice. --Here again it should be stressed that rice quality is in general evaluated by two standards: (1) How well it works in our process, and (2) by the absence of any flavor influence. We have evaluated several samples of parboiled rice in the laboratory and twice in our brewhouse. Parboiled rice causes us some difficulty in both of these categories. We have observed what might best be described as cooked vegetable odors in heated parboiled rice samples, and we have experienced variations in conversion time when parboiled rice was used. Since

1/ Halick, J. V., Beachell, H. M., Stansel, J. W., and Kramer, H. H. 1960. A note on the determination of gelatinization temperatures of rice varieties. Cereal Chem. 37(5): 670–672.

we wish to have the brewers' rice operate properly in an efficient brewhouse operation, this variation in conversion time causes some concern. We do not wish to have our adjunct handling and conversion steps regulate the operation of the brewhouse.

To conclude, at Anheuser-Busch we prefer to use rice. We will continue its usage if the cost penalty does not become too severe. Our technology on brewers' rice is largely limited to those features which we feel are quality aspects for our purchase and use of rice.

DISCUSSION

Question: Do you use any special preservation methods, say refrigeration, for brewers' rice?

W. A. Hardwick: We use a dry silo type storage.

Question: Is the oil limit you mentioned 0.75 percent or 0.75 parts per million?

W. A. Hardwick: 0.75 percent.

CHARACTERISTICS DESIRED IN RICE FOR ADOLPH COORS COMPANY

by
W. E. Hays
Adolph Coors Company
Golden, Colo.

The characteristics in rice desired by Coors are probably quite different than those desired by the housewife. One of the most important of several characteristics of rice from Coors brewing standpoint if gelatinization temperature. This temperature must be low enough to prevent the destruction of the enzyme, alpha amylase, present in barley malt. This enzyme is responsible for the liquefaction of the rice starch. The method of determining gelatinization temperatures is a laboratory pilot brewing test that is performed on a composite representative sample from each carload received. This test simulates Coors production brewing using the same proportions of ingredients, the same temperature pattern, and involves the same length of time. In this manner, several hundred tests were made on various varieties of rice grown in different environments. Short-, medium-, and long-grain varieties of regular and glutinous (waxy) rice were collected by Webb, Bollich, and Beachell at the Beaumont Station.[1/] It is now better known what to expect from a given variety grown in a geographic area under certain climatic conditions. The highly milled samples from a given variety tended to have a beneficial effect on cooking characteristics from the standpoint of brewing at Coors. Fineness of grind also seems to change the cooking qualities. B.D. Webb found similar results.[2/]

The desire for carefully milled rice comes from problems of viscosity due to high fat content. Poorly milled or undermilled rice leaves some of the bran on the kernel thus increasing oil or fat content. Coors has required that rice contain a minimum of fat, which helps to assure better viscosity. Field damaged kernels may harbor microorganisms and cause odor or flavor that is unsatisfactory. This would be more prominent in undermilled rice. Improper drying of rough rice, causing stack-burn or sour rice would render it unsuitable for use at Coors. Carloads have been refused because of this problem.

Weed seeds present in brewers' rice is known from laboratory tests to cause an odor in some cases similar to legumes, such as sweet clover. This, of course, is objectionable. The more nearly the rice approaches an absence of odor the better it seems to suit our use.

Burlap was once a source of odor that has been overcome for the most part. The early shipment of brewers' rice in hopper cars is very desirable. Various varieties or types of rice have aromas that can only be detected by physical smelling of the pilot cooking tests. This makes it difficult to explain or to work with. An example would

1/ USDA, ARS Cooperative Agreement No. 12–14–100–5395(34). 1963–1964. Between USDA and Adolph Coors Company.
2/ Webb. B.D. and Bollich, C.N. 1963. Annual progress report to cooperators. Cooperative Agreement No. 12–14–100–5395(34).

be that Bluebonnet has a distinctly different aroma than Nato or Calora.

Valuable projects for the USDA Utilization Research workers that would help this Company would be to develop more neutral smelling, low gelatinization rice starch. The work with separation of rice flour from the rice kernel may well be an answer.

More effective ways of removing weed seed and other impurities from brewers' rice would be a great help.

Methods of obtaining a uniform rice starch under different environmental conditions would be of much value. Even the same variety grown under varied conditions tends to have different characteristics.

Research work carried on with the cooperation of the USDA State Universities and State and County Extension Services include trials to test the effect of high nitrogen applications on Colusa rice at Biggs, Calif. 3/ This was to determine effect on field yields and on brewing quality. Field yield and quality tests were made on experimental varieties with the cooperation of the Agricultural Research Service and Texas Rice Improvement Association near Houston and Beaumont, Tex. 4/ Variety tests were conducted on short grain rice varieties in Louisiana and in northeastern Arkansas and southeastern Missouri. These were on private farms and in cooperation with the Extension Service and local rice mills. In all cases, Adolph Coors Company guaranteed the cooperator(s) a return equal to or above that received for regular production rice. All experiments were grown under government allotment regulations.

Other areas of research include a research grant 4/ with the ARS and a study of rice availability by Stanford Research Institute. 5/ Coors rice research costs in excess of $10,000 per year.

DISCUSSION

Question: What role does protein content play?

W. E. Hays: Clouding is an important consideration.

Question: Do amino acids affect the flavor?

W. E. Hays: Very little work has been done on this.

Question: Will the Stanford report be available?

W. E. Hays: Yes

Question: Do you have a problem with pesticide residue?

W. E. Hays: Yes, this is a problem. Methyl bromide is used as a fumigant during storage. The Food and Drug Administration would prefer that we use nothing. At present we make sure that methyl bromide concentration is less than 10 parts per million before the rice is used.

3/ Mueller, Kenneth. 1963. Biggs Research Station. Personal communication.

4/ See footnote 1, p. 64.

5/ Mainwaring, Thomas A. 1965. An evaluation of alternative possibilities for rice procurement. Stanford Research Institute. Menlo Park, Calif.

THE MARKET POTENTIAL FOR FOOD PRODUCTS–THE NEXT 10 YEARS

by
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J. Walter Thompson Company
Chicago, Ill.

Agriculture and the food industry enter 1966 in a healthy and vigorous condition which augurs well for American consumers. United States food producers and manufacturers have contributed to the development of a food supply system that is the envy of the world.

For the most of us here in attendance today--the consumer is our business and she is showing a greater willingness to exercise her prerogatives in the market place. Patterns of food consumption today are changing rapidly to meet popular desires world-wide.

True, we have always had change, but today, what is new is not change but the rate of change.

In the next few minutes I would like to discuss with you some of the economic and social trends that influence worldwide markets for food products.

Today's needs are founded in the whole social and economic structure of the world and are being influenced by rapid and dynamic changes. Rapid growth in productive ability, for instance--particularly in Western Europe, Japan, and the United States, is bringing about these dynamic changes in world markets.

All of us who have a part in the production, research, development of new products, and marketing of products should be aware of these trends since it is the consumer and the potential upgrading of his standard of living that is fast becoming the real key to economic growth.

There are eight factors of dynamic change in the United States which I believe should be watched closely in developing market plans during the next 10 years. In varying degrees, these changes in the U. S. are forecasting similar trends in other world markets. The factors that I am referring to are:

1. The overall growth of the economy.
2. The increase in goods and services.
3. Income per household and movement upward in income groups--giving mass millions of the U. S. population more money to spend and with it more independence--and with that independence more selectivity.
4. Population growth and the shift of that population within the United States--the movement toward larger urban areas.
5. Changing patterns of food preference and consumption.
6. The development of new food products--which is in keeping with our economic and social progress.
7. The increase in competitive efforts to change people's habits and likes.
8. Changes in worldwide markets for food products.

Time will not permit me to discuss all these factors--so I've elected to discuss briefly some of the more important ones.

Overall Growth of the Economy

We have to take a good aim at our future course of direction for agricultural products in the next decade.

An analysis of the potential improvement in living standards in just two areas of the free world--Western Europe and the United States--indicates an addition of over $400 billion in personal consumption--that's consumer demand for goods and services--in the next 10 years. Hence, the potential addition to markets through the upgrading of total standard of living in these two areas in the next 10 years alone far surpasses the total growth of Western Europe and the United States in all history up to 1950.

Now, very little attention has been paid to the fact that the productivity of a Nation's people cannot be stimulated and utilized without upgrading the standard of living and expanding the sales of goods and services to match production and thus provide employment and income commensurate with the improved productive ability.

Nor have we fully recognized that expansion and improvement of plant and equipment, and interest in private investment, depend ultimately on growth in consumption. No industry can continue to invest in expansion, or improvement, or in research and development of new products and services without soundly based hopes for demand, via advertising and sales promotion efforts, for its products and an environment of profit potential in the sale of these products. Agriculture is no different than any other industry.

There is only one way that plant and equipment investments can be amortized and that is through sales and profits. Yet, let's see what has happened during the past 6 years The rate of total investment in new plant and equipment increased 63 percent between 1959

and 1965 and investment in new manufacturing plant and equipment increased 92 percent. The increase in advertising volume during the same period of 6 years was only 36 percent, and total personal consumption increased only 36 percent. This is less than half the rate of growth in expenditures for new plant and equipment in manufacturing.

This rapidly increasing capacity to produce and the rapidly growing pressure for employment will revolutionize our ideas of needed growth in consumer demand, and the amount of investment in public relations, advertising, and selling effort needed to educate, encourage, and stimulate that consumer demand.

The Potential Food Market by 1975

The potential market for food could total well over $125 billion by 1975--an increase of 47 percent over present sales (fig. 1). That means an opportunity of adding about $40 billion on top of the 1965 food sales.

The probable growth of our national economy to over $1 trillion of total productive ability by 1975-1976 is now widely predicted by economists. This means an expansion of about $220 billion in total personal consumption, or sales to consumers, to a level of over $640 billion compared with present personal consumption expenditures of $420 billion.

Food Expenditures Per Capita Now Increasing 2 Percent Per Year (In Constant Prices)

From 1940 to 1950 food increased its share of the total standard of living expenditures from 23 percent to 24 percent, then dropped back to 23 percent in 1955, and continued to drop to 21 percent in 1960. This downward trend stopped, and reversed itself. Per capita consumption of food increased 10 percent in the next 5 years. A continuation of this 2 percent gain per year in per capita consumption indicates a further growth of over 23 percent to about $540 by 1975-1976--and, I repeat, a total food market of $125 billion.

Average Income Per Household Should Grow to $11,300 by 1975

Another barometer is our production ability which by 1975 whould provide about $790 billion of personal income for consumers with an average of $11,300 per household for the 70 million households we are expected to have in 1975. This is about 23 percent above the average of $9,170 in 1965.

Family Real Income Expanding--Revolutionary Change in 14 Years 1950 to 1964

In the 14 years, 1950 to 1964, the number of families in the U. S. with real incomes over $10,000 increased 286 percent (fig. 2). In other words, by 1964 there were nearly 4 times as many families having $10,000 annual incomes as existed 14 years before.

By the same token, families with under $5,000 real income declined 33 percent.

This really means that the climb upward in income groups will continue to expand the opportunities for upgrading all standards of living by consumers, including food products.

Revolution in Distribution--Shift to Self-Service, Supermarkets and Shopping Centers

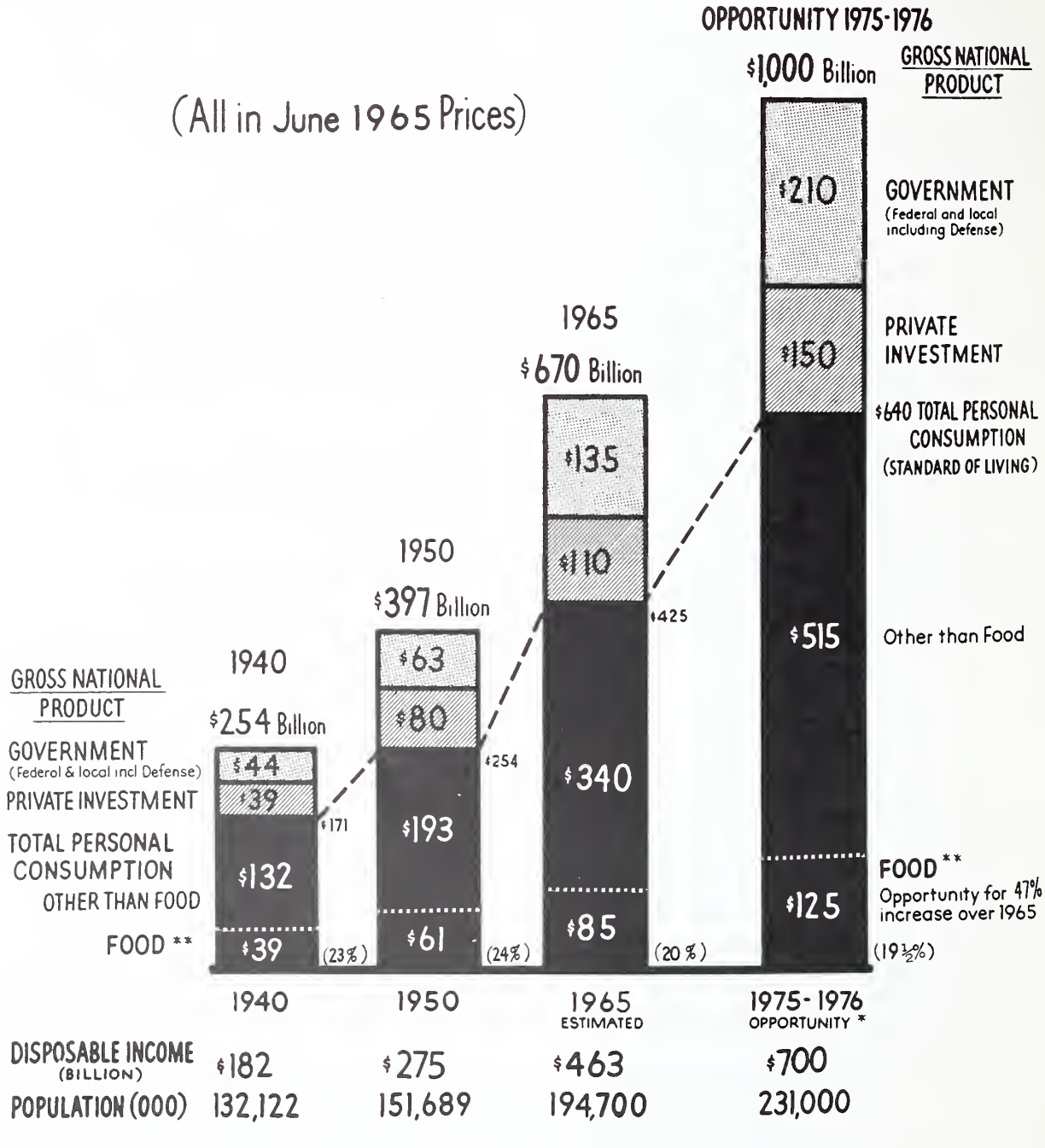
Along with the climb in incomes, the shift to the suburbs, and the growth of shopping centers since 1950, there has been a revolutionary change in distribution to match the changing population. Rapid growth of discount merchandising and of self-service in supermarkets, drug stores, and other outlets is increasing the importance of advertised products with well-developed consumer preference. As an example of the revolution in distribution consider the changes in grocery-store distribution in the 10 years from 1951 to 1961 (fig. 3).

In 1961, 30,000 supermarkets with total sales of $38.2 billion had an $8 billion greater total volume of business than all the 394,000 grocery stores in existence in 1951--only 10 years earlier.

Representing only 12 percent of the stores in 1961, the supermarkets had 70 percent of the volume of sales. An additional group of 55,000 superettes, representing 22 percent of the stores, accounted for 22 percent of the volume. Two classes of stores--supermarkets and superettes--with only 34 percent of the stores, handled 92 percent of the grocery volume.

FOOD PRODUCTS

OPPORTUNITY FOR 47% GREATER MARKET BY 1975



* Based on Probable Population Growth and a minimum increase in production per capita of 2.4% per year

** Food - Excluding Alcoholic Beverages

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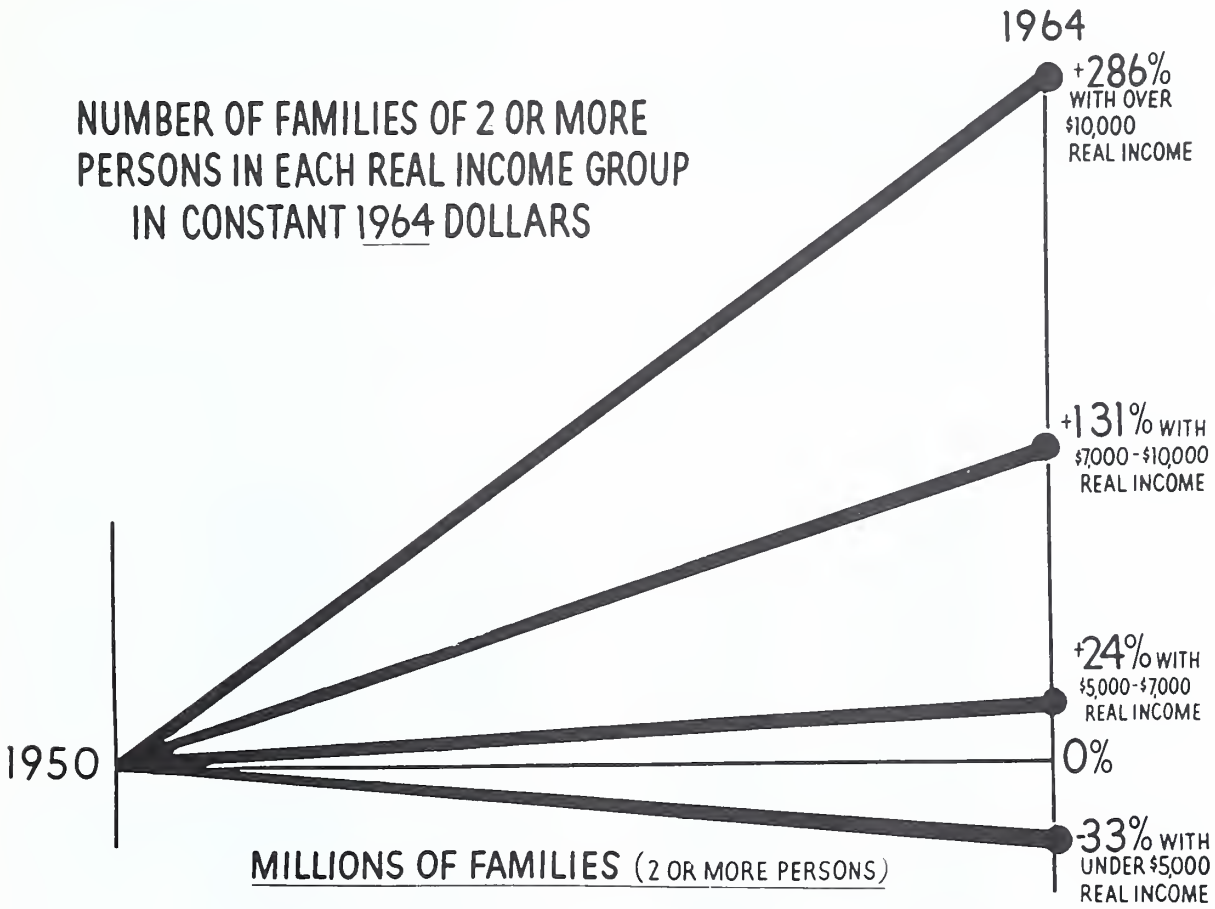
Figure 1

FAMILY REAL INCOME EXPANDING REVOLUTIONARY CHANGE IN 14 YEARS 1950-1964


1964
+286% WITH OVER $10,000 REAL INCOME
NUMBER OF FAMILIES OF 2 OR MORE PERSONS IN EACH REAL INCOME GROUP IN CONSTANT 1964 DOLLARS
+131% WITH $7,000 - $10,000 REAL INCOME
+24% WITH $5,000 - $7,000 REAL INCOME
1950
0%
-33% WITH UNDER $5,000 REAL INCOME
MILLIONS OF FAMILIES (2 OR MORE PERSONS)

FAMILY INCOME	1950 CURRENT DOLLARS	1950 1964 DOLLARS	1964 ACTUAL 1964 DOLLARS	1964 % CHANGE
OVER $10,000	1.2	2.8	10.8	+286%
$7,000 TO $10,000	2.4	4.8	11.1	+131%
$5,000 TO $7,000	5.6	7.6	9.4	+24%
UNDER $5,000	30.7	24.7	16.5	-33%
TOTAL FAMILIES (MILLIONS)	39.9	39.9	47.8	+20%
MEDIAN INCOME	$3,319	$4,235	$6,569	+55%

Source Bureau of the Census Series P-60, No 44 May 27, 1965

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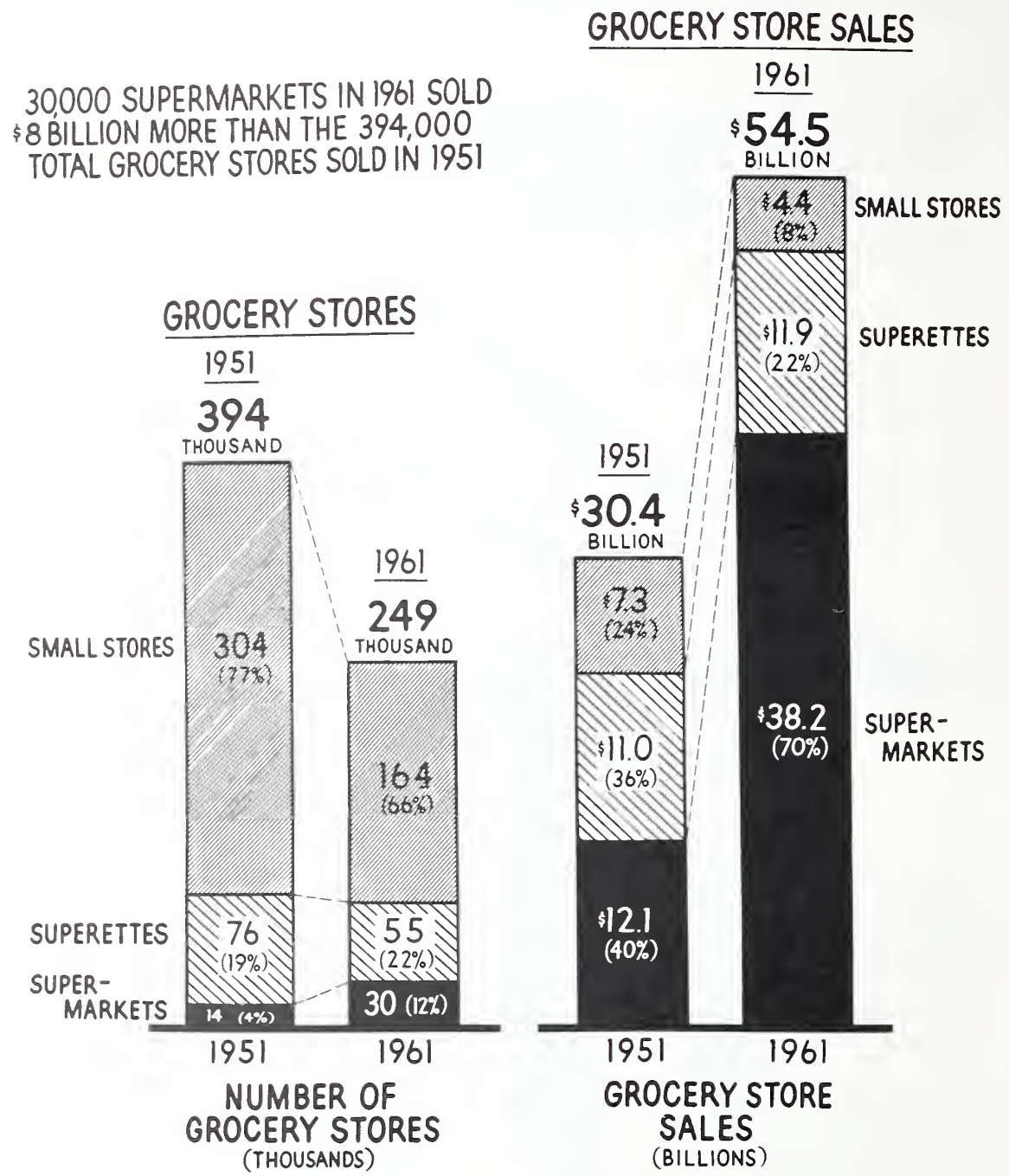
Figure 2

REVOLUTION IN GROCERY STORE DISTRIBUTION IN 10 YEARS – 1951-1961



Source PROGRESSIVE GROCER

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Figure 3

Along with Changing Food Distribution is the Changing Patterns of Food Preference and Consumption

A recent qualitative study made for my firm, the J. Walter Thompson Company, among "middle majority" housewives in four major cities of the United States brought to light many interesting facts about today's attitudes toward food and its consumption among women of all ages. Of particular significance are those references to the remarkable differences in points of view of grandmother, mother, and daughter, and what young housewives regard their roles to be relative to their families. Here are some of the pertinent quotes from the study:

1. "Her role has shifted in keeping with our changing society. But the central function remains. We eat to live. The nurturant role is vital."

2. "For the ethnic grandmother or the depression mother, quantity was a grave issue."

3. "Today, quality is the issue replacing quantity. Whether cooking or shopping, today's woman wants quality. She wants reassurance of freshness as a part of this. For her, an expiration date clearly visible on every item sold would be a relief."

4. "Grandma usually cooked as her mother did. We can all remember, I'm sure, that there was a sameness about her meals--and was it good."

5. "Mother in today's kitchen is knowledgeable and concerned about nutrition, health, and weight. She often has a calorie-counter at hand in the kitchen. She knows about the specific content of vitamins, minerals, proteins, carbohydrates, and even cholesterol content in many foods. She may prepare separate dishes for various family members, but more frequently feeds the whole family in the same way."

6. "The age of plenty, of information, of artificial processing, and of mechanical aids has produced more sophistication. People are willing to try unaccustomed foods, particularly when the preparation is short and time saving."

7. "Middle-class wives and mothers are proud of the fact that the family eats what she chooses to give them--everything."

8. "These excerpts from an authoritative body of information indicate clearly that today's (and tomorrow's) 'middle majority' housewives are ready for and susceptible to change in family food habits. Product publicity, advertising, and promotion efforts directed against them by the food industries can influence them."

Development of New Products

One of the truly major developments which I think agriculture and the food industry must deal with in the next 10 years is that of synthetic foods, such as the oilseed proteins which several companies are now developing. Whether they come from oilseed proteins, or from bacterial production of petroproteins, or from the ocean, or from the forest, all of which have been in the news recently and could eventually be capable of providing ample quantities of low cost foods--I'm convinced as I can be that the time is near when we will face a whole new array of manufactured foods.

And to those people who say it won't or can't happen, that it is too costly, or that people won't use such foods, may I gently refer you to rayon, nylon, and other synthetic fibers, to synthetic rubber; and to the fact that nearly all our soaps and detergents in use today are synthetic. If I still have not convinced you, let's proceed further:

The redblooded male can spray himself with 007, Teak, No Doubt, Pub, Rip Tide, and Passport 360--these are just some of the new men's toiletry lines that have sprung up in recent months.

Twenty-five years ago men's toiletries consisted mainly of hair oils and after-shave lotions and accounted for $127 million in sales. Now they include sun tan formulas and hair coloring and are approaching the half-billion-dollar level.

Last year Americans bought $210 million of frozen prepared dinners, some 3 million color TV sets, $235 million of canned dog foods.

Once this might have been called conspicuous consumption. Today, it merely illus-

trates the array of goods and services to which Americans--with more money than ever--are exposed to and will buy.

Velocity of Change in Living Standards Parallels Growth in Communication and Advertising

The velocity of change in living habits in the U. S. in the last 25 years--since 1940--has been startling. This is evidenced by the fact that 84 percent of the growth in personal consumption expenditures, representing the total standard of living, has taken place in the last 25 years or between 1940 and 1965--only about 16 percent of the growth occurred in the first 75 years. (See fig. 4).

This rapid improvement in living standards of the last 25 years was coincident with the growth of communication and advertising influence--86 percent of the growth of advertising has occurred in these 25 years.

This has a real significance in indicating the economic importance of advertising because only 39 percent of the U. S. growth in population has taken place in the last 25 years. Sixty-one percent of the 100 year population growth occurred during the first 75 years which represented only 16 percent of the growth in consumption expenditures and only 14 percent of advertising growth. Even if the consumption figures are corrected to a constant dollar, in terms of 1964 prices, we still must realize that 63 percent of the growth in physical volume of consumption has occurred during the last 25 percent of the Century with only 37 percent taking place in the 75 years accounting for 61 percent of our population growth.

Particularly in the United States, Western Europe, and Japan, the rapid expansion of productive capacity expected in the next decade will force attention on the expansion of markets through the educational force of advertising on upgrading of living standards.

Growth of Competitive Efforts to Upgrade Living Standards

A new concept of advertising as an economic force is becoming apparent in the enlightened free nations of the world--those nations which are striving for rapid economic growth, full employment, and improved living standards.

This concept centers around the growing recognition that advertising of specific products and services becomes a powerful and dynamic force in economic growth--and that the expansion of markets through encouragement of a better standard of living is in the public interest.

Illustrating this velocity of change--in 10 years, from 1940 to 1950, total advertising influence directed to consumers grew by $3.6 billion. Then, in the next 15 years, from 1950 to estimated 1965, another $9.3 billion of advertising influence on the consumer has been added--an increase of 163 percent. That's over seven times the prewar total! (See fig. 5).

To sell the volume of goods and services necessary to support the $1 trillion potential level of production in 1975 in the United States alone could well require about $30 billion of total advertising--or over double the present.

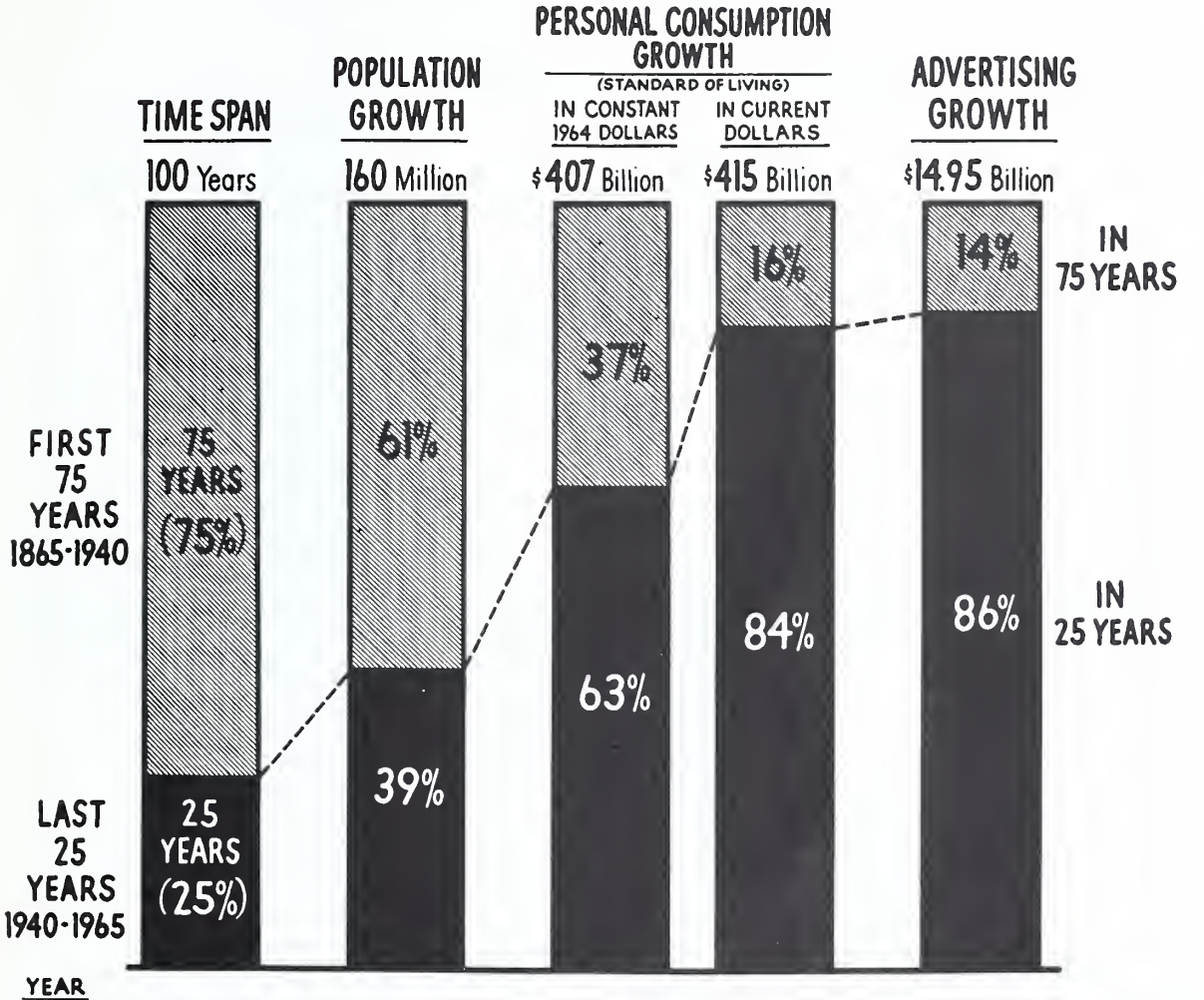
In two areas alone which have been used as examples--the United States and Western Europe--the potential market for sales of consumer goods and services should expand by over $400 billion within the next 10 years--from present levels of about $700 billion to about $1,100 billion by 1975-1976.

And this potential growth in consumer demand could stimulate correspondingly rapid increases in these markets for industrial and agricultural goods and for world trade--exports and imports. Add to this the potential growth in production and living standards in Latin America and Canada, free Asia and Africa, and it can be seen that growth of world markets in this "Decade of Opportunity World-Wide" could be really explosive--explosive in the sense of marketing opportunities for agricultural products and a new velocity of improvement in living standards.

American agriculture and the food industry have done a remarkable job to date but the competitive road is getting--rather crowded. Thus, it will take a substantial and renewed effort on the part of commodity organizations to assure themselves of a larger and more profitable share of market for their products. The value of commodity programs which utilize advertising and product promotion activities without question have demonstrated many times over their real value to assist in

IMPACT OF ADVERTISING GROWTH

86% OF GROWTH HAS OCCURRED SINCE 1940- ONLY 14% IN FIRST 75 YEARS OF THE CENTURY



YEAR				
1865	35 MILLION	$13 BILLION	$5 BILLION	$0.05 BILLION ($50 MILLION)
1940 - 75 YEARS LATER	132 "	$165 "	$72 "	$2.10 "
1965 EST. - 100 YEARS LATER	195 "	$420 "	$420 "	$15.00 "
GROWTH IN FIRST 75 YEARS (1865-1940)	97 "	$152 "	$67 "	$2.05 "
GROWTH IN LAST 25 YEARS (1940-1965)	63 "	$255 "	$348 "	$12.90 "

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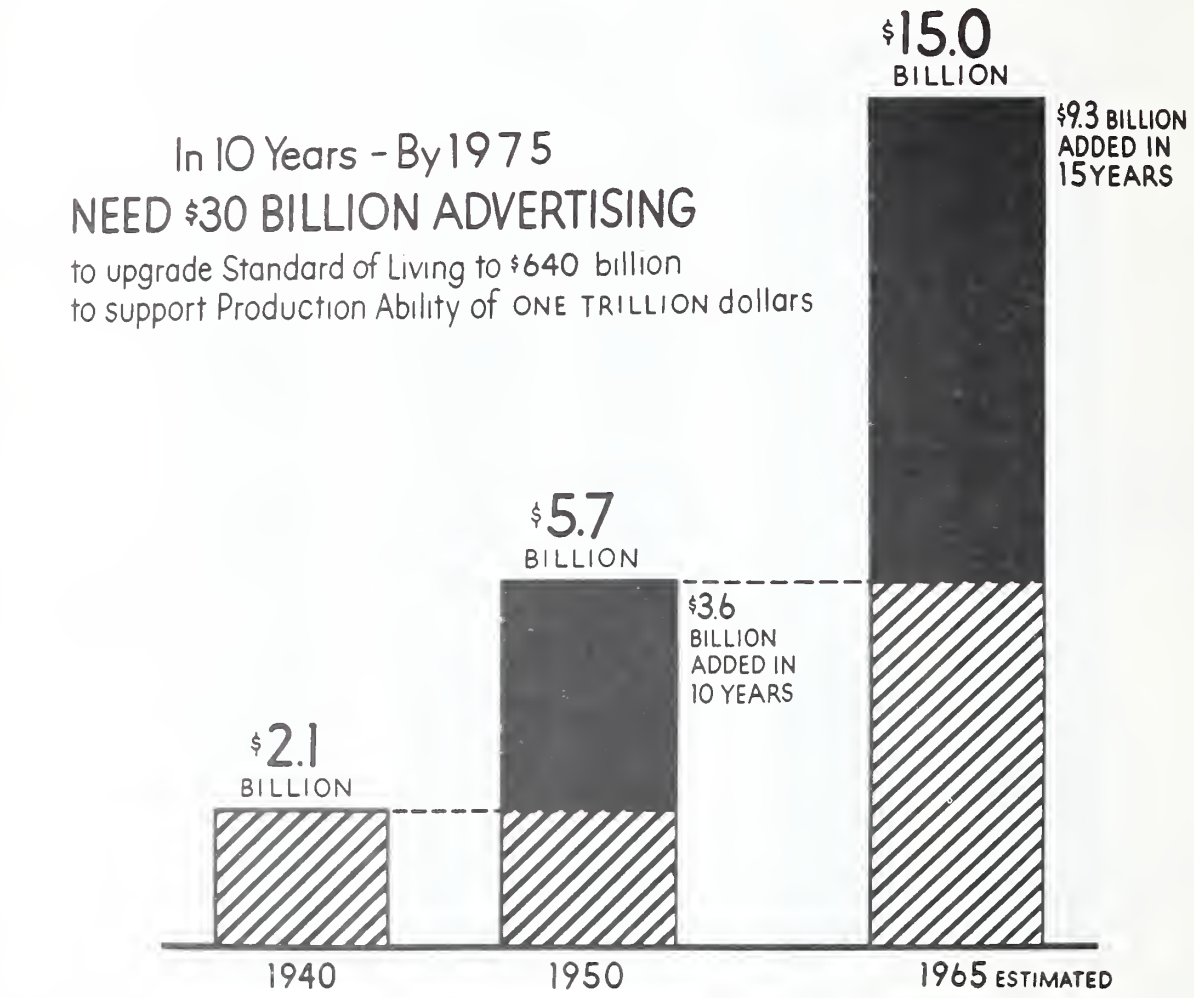
Figure 4

COMPETITION

HOW TOTAL ADVERTISING INFLUENCE ON THE U.S. CONSUMER HAS INCREASED


In 10 Years - By 1975
NEED $30 BILLION ADVERTISING
to upgrade Standard of Living to $640 billion
to support Production Ability of ONE TRILLION dollars
$15.0 BILLION
$9.3 BILLION ADDED IN 15 YEARS
$5.7 BILLION
$3.6 BILLION ADDED IN 10 YEARS
$2.1 BILLION
1940
1950
1965 ESTIMATED

ADVERTISING			1960	
NATIONAL	$ 1.2 BILLION	$ 3.3 BILLION	$7.3	$ 9.3 BILLION
LOCAL	$ 0.9	$ 2.4	$4.6	$ 5.7
TOTAL	$ 2.1	$ 5.7	$11.9	$ 15.0
POPULATION (July 1st)	132 MILLION	152 MILLION	181	195 MILLION
$ PER CAPITA	$ 16	$ 38	$66	$ 77

J. WALTER THOMPSON COMPANY

Source 1940 to 1960 estimates by Printers' Ink

Figure 5

the movement of more products into consumer channels in the U. S. and abroad.

If agriculture and the food industry are going to be competitive in the next 10 years, it will take considerable joint effort--by all of us who have a part in the food business to achieve, motivate, and engineer the important stimulant that agriculture will need to keep pace with our changing society, living habits, and consumer demand that is fast becoming our way of life.

To move forward one must constantly evaluate--be prepared for the future--it's not what's new--but what's new and better.

THE STORY OF AMERICAN RICE--INTRODUCTORY COMENTS ON FILM

by
L. O. Tiedt
Rice Council for Market Development
Houston, Tex.

"The Story of American Rice" is a full color motion picture produced as a joint project of the United States Department of Agriculture and the Rice Council for Market Development as a major contribution of the United States toward International Rice Year.

This film depicts the modern efficiency of the American rice industry, emphasizing mechanization, its use of the latest production techniques, and its concern for quality control, and cleanliness of the product from field to family table. Special emphasis is placed on the quality of the American rice and the attention given toward maintenance of this quality to ultimate consumer.

This film will be utilized by the Rice Council for Market Development, on behalf of the American rice industry, as an educational device to show the peoples of the world that clean high quality rice is produced by the American industry. Translations of the audio portions of the film will be made in at least 9 foreign languages, and the film will be distributed into at least 30 foreign countries where there is potential for increased sale of American rice.

SUMMARY OF CONFERENCE

by
E. E. Edmundson III
Edmundson-Duhe Rice Mill, Inc.
Rayne, La.

One of the real values of this conference has been to emphasize the urgency of the challenge facing the rice industry and, in fact, the entire food industry. The great increase in food production which will be necessary to feed the increasing world population will require rapid and substantial expansion of processing facilities both in this country and in underdeveloped countries. It is very important to expand at the most advanced and efficient technological levels possible and not increase our investment in outmoded plant and equipment. This advanced technology and greater efficiency can only be achieved by continuing and expanding the research done by the Southern Regional Laboratory and other facilities.

One of the first problems facing the rice industry in meeting this challenge is understanding the nature and possibilities of the rice grain; how the physical properties are related to the chemical. The question, "What is rice?", may be very simple, but the answer is extremely complex and has led to many interesting developments. In this area there are many specific projects--such as objective determination of cooking characteristics and viscometric properties; chemical composition of different rice layers; changes due to storage and aging; effect of fungi on composition and color of grain; determination of nutritional value of rice, especially amino acid relationships; the chemical nature of bran adhesion; further

study of high-protein flour from broken or brewers' rice, to determine if it can compete with such cheap sources of protein as soybean meal; and development of a rice variety with a much higher protein content. This is all very interesting and basic research. It may have specific applications such as high protein flour, in fact it will probably have many; but, the more we know about the chemistry of the rice grain, the better equipped we are to handle any problem on rice.

The next major field of concentrated research which is being dealt with, especially today, is the problem of determining just what we require of rice; what characteristics are desirable in rice for brewing, for canning, for all the different types of processing, and how we measure these characteristics.

To a large extent these questions are being answered by companies involved in purchasing rice for these various purposes, and they have methods of making their suppliers aware of their needs. But it is highly important that the people doing basic research, as well as the processing part of the industry, be well informed as to these requirements so that we can hope for a productive fallout of specific applications from the more basic research which the government is doing. Specialty and processed products have been greatly increasing in importance as an outlet for rice, and will continue to do so as other countries become more affluent and, therefore, receptive to convenience foods. This conference has been especially helpful in highlighting these very specialized problems.

However, there is one area where we need to make a special effort to understand--that is, the requirements of the underdeveloped countries. These countries may be happy to take what they can get now on a give away basis, be it seedy rice, burlap odor, poor nutritional value, or unreliable cooking characteristics, but it is very much in our interest to have these countries develop a preference for American rice as a quality product that meets their particular need since that preference will be a great asset when these countries, like Japan, become strong enough to buy for dollars.

In addition to further defining the requirements for existing uses of rice, there is the extremely promising possibility of developing new and better use of rice. The high protein rice flour is one such exciting possibility. Many other prospects, such as popped rice products, dehydrated rice flakes, and noodle-like rice products are being held in abeyance for lack of funds. Many of these products, such as high-protein rice flour, can be made from brewers' rice, and may possibly become more attractive economically as rice production is increased and the supply grows in relation to demand.

Finally, there are the problems of processing. We are gradually defining and measuring just what is desirable in rice from many different viewpoints. We are slowly, but steadily, gaining a better knowledge of what rice is, but the possibilities of improvement in efficiency and technology all but stagger the imagination. Perhaps the most startling development is the prospect of a solvent milling method which could change the entire industry. Perhaps the lye method can be developed to yield useful byproducts from the bran and oil so that it will be more economically feasible. Certainly lye is preferable to hexane from a safety standpoint. There is an incredible number of possible advances in this field all the way from investigation of special techniques, such as infrared drying, to better methods for material handling; from chemical change of cooking characteristics to development of stable and balanced additives for rice enrichment; from development of new varieties to cheaper precooking processes. The utilization laboratory is developing methods for transforming any type rice into cooked products of any desired firmness, texture, and viscosity, whereas the plant breeders are carefully limiting the cooking characteristics they select to the characteristics of established varieties. If we could breed a medium grain variety retaining typical higher yields and much lower price, with the premium cooking characteristics of long grain rice, we would certainly have a price and quality advantage in the world market. Many possibilities mentioned are still in the development stage and doubtless some of them will prove impractical, but the number of important successes in the recent past, such as parboiling, quick cooking, and multipass drying, has been large. And, as Dr. Fisher so thoroughly brought out, there is every indication that additional expenditures for research will be highly productive in terms of new technology. Yet in spite of the high return per research dollar and the current critical need for improvement

and expansion, the research effort is being hampered by lack of funds. Even if rice research funds are allocated on the basis of the dollar value of domestic farm output, several plans now being considered, such as the two price system, which will enable the American Farmer to meet the rapidly increasing foreign demand for rice with little or no government subsidy and the rapid increase in domestic demand brought about by the introduction of convenience rice foods and the Rice Council Campaign, all point to increases in production and hence justifiable increases in rice research. If the importance of rice as a major world food is considered, even greater increases in research can be justified. I hope that the members of the rice industry can help call attention to this needed increase.

Perhaps the most important benefit of a conference such as this is to help foster a communication and dialogue between the different segments of the rice industry, the millers, the specialty users, and the research workers. Certainly much valuable work is being done by these different segments and the interchange of ideas is very stimulating. The prospects for change and improvement in the rice industry are staggering.

I hope that you have all been as excited and stimulated by this conference as I have, and I know that we all wish to thank the many members of the research staff at the Regional Laboratory for their time and concern in holding this conference and giving us all a chance to share viewpoints.

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